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BACTERIOLOGICAL, CHEMICAL, AND BIOLOGICAL STUDIES OF RECONSTITUTED MILK

By RAYMOND RANDALL

Major, Veterinary Corps, United States Army
Member, United States Army Medical Department Research Board
Bureau of Science, Manila

THREE TEXT FIGURES

INTRODUCTION

Milk and milk products, because of their high nutritional value, are components of the soldiers' ration and properly demand a place in any well-balanced diet. Their use by the people of the United States has increased to such an extent that dairies now constitute the country's largest single industry, producing fourteen billion gallons of cow's milk yearly. In spite of this, a local supply of cow's milk is not always available in quantity or quality for the use of military personnel. This is especially true in the Tropics where the native cow on native feed produces but little milk in excess of her calf's requirements. The daily supply available for the City of Manila amounts to only about 1,100 liters. There is about the same amount of carabao milk available, but this does not alter the situation for the military personnel.

Under these conditions, the Army has depended in the past largely upon canned evaporated milk. This has the advantage of being a sterile product and available in almost unlimited quantities. An undesirable feature in the use of canned evaporated milk is the prevailing method of piercing the top of the can with an ice pick or meat cleaver, pouring out part of the

contents, and setting aside the remainder for future use in a condition easily subject to contamination.

In more recent years, whole-milk powder has been available. Its great advantage is the decrease in bulk through the removal of about 97 per cent of the water from the whole milk. As stated by Hunziker,(1) the disadvantages of whole-milk powder are the deterioration of the fat with age, the alteration of the flavor through the comparatively rapid changes that occur in the exposed powder, and the tendency to spoil under ordinary conditions of commercial storage and marketing. When vacuum packed in small containers, the deleterious changes occur more slowly, and the contents of the opened can are more apt to be used before oxygen and moisture can act on it. For use, whole-milk powder should be mixed in sterile containers with potable water and in such amounts as to assure consumption within a short period of time and the mixture must be handled as is natural milk.

A third form of concentrated milk is skim-milk powder. This is made from skim milk and contains from 2 to 4 per cent water and usually from 0.5 to 2 per cent butter fat. Hunziker states that properly manufactured skim-milk powders are comparatively stable and retain their freshness for many months, provided they are packed in air-tight, moisture-proof containers; but that they will eventually develop a stale flavor from changes in the fat, small in amount as the latter is compared with the 28 per cent of fat in whole-milk powder. It is used in cooking and in making reconstituted milk.[1]

Reconstituted milk is now produced by one firm in Manila and its use by the military personnel has grown to such an extent as to prompt the writer to investigate it from bacteriological, chemical, and biological standpoints.

Reconstituted milk is a homogeneous mixture of skim-milk powder, sweet (unsalted) butter, and water. The skim-milk powder is imported from California in wooden barrels and is held in cold storage until used. The powder is stated to be produced by the Gray-Jensen spray process. In this process

[1] An idea as to the extent to which these concentrated milks are used can be gathered from the statement in a publication of the Philippine Bureau of Animal Industry that it requires 55,000 acres of United States' land to pasture the cows that annually yield the 58,000,000 pounds of natural milk that are exported to the Philippine Islands in condensed and evaporated form. This constitutes approximately 80 per cent of the dairy products imported into the Islands.

the skim milk is preheated to about 170° F. in a storage tank by passing it through flash heaters connected with this tank, then pumped through a series of spray nozzles into a precondensing chamber where the milk is maintained at 165° F. by hot air circulating from the final drying chamber. At this point there is some evaporation. From this chamber it is pumped under about 2,500 pounds' pressure into the final drying chamber through overhead spray jets. Dry air at about 260° F. enters this chamber from the bottom and removes about 98 per cent of the moisture from the milk, which then falls to the bottom of the chamber as fine, flaky particles. This dried milk is drawn by air into a collection tank where it is fed into a hopper and through a flour bolter to insure the fineness of the powder. It is then run into the shipping containers.

Sweet (unsalted) butter is shipped from Australia, refrigerated, in wax-paper-lined wooden boxes of about 56 pounds' capacity. The available scores of the inspectors of the Australian Commonwealth show that the butter at the time of inspection in Australia is of the choicest quality. Butter to score this high can be made only from cream that is fresh and of high quality. On arrival in Manila the butter has a clean, pleasant flavor and aroma, necessary qualities to produce palatable reconstituted milk.

Reconstituted milk is made by agitating at a temperature of 143° F. for thirty minutes the proper amounts of sweet butter, milk powder, and artesian water in a glass-lined pasteurizer that is provided with a water-heated revolving spiral coil. This operation melts the butter, dissolves the powder, thoroughly mixes the ingredients, and pasteurizes the product. The milk, after running through tubular filters to remove any extraneous or undissolved matter, goes to a homogenizer where it is subjected to a pressure of from 2,500 to 3,000 pounds to the square inch. This thoroughly emulsifies the fat and prevents it from separating out in the bottled product. From the homogenizer the milk passes through an internal tubular cooler where its temperature is reduced to about 40° F. It is then bottled and capped by one machine, and another machine places hood caps over the tops of the bottles to protect their lips from contamination. The bottles are then placed in storage below 40° F. until delivery. The milk bottles and crates, before being used, are washed in a standard washing machine.

The advantages of properly prepared reconstituted milk are: first, the water and other ingredients used are pasteurized;

second, the containers are properly cleansed before being filled; third, from the time the ingredients are pasteurized and including the bottling of the product, there is no human contact.

BACTERIOLOGICAL EXAMINATIONS

The bacteriological examinations of the water used in the reconstituting plant and the *Escherichia coli* determinations were made according to the methods prescribed in Standard Methods of Water Analysis.(2) The macroscopic colony counts and Breed method counts were made as prescribed by the American Public Health Association and the Association of Official Agriculture Chemists.(3) The skim-milk powder was accurately weighed in sterile tared flasks and diluted 1: 10 with sterile freshly distilled water and shaken until dissolved. The macroscopic colony and Breed method counts were recorded as bacteria per gram of skim-milk powder.

Examinations for the presence of viable *Mycobacterium tuberculosis* in the butter and skim-milk powder were made as follows: Two grams of the butter were melted in warm normal salt solution and centrifuged, and the sediment and supernatant fat layer used for inoculations. Two grams of the milk powder were dissolved in 20 cubic centimeters of distilled water and centrifuged; the sediment was suspended in 5 cubic centimeters of normal salt solution and used for inoculation. The inoculations were made subcutaneously into the groins of guinea pigs. The animals were weighed and kept under observation for two months, when they were autopsied.

Examinations of the skim-milk powder, butter, water, and the finished product were made at monthly intervals. The bacteriological findings for three representative months are given in Table 1. The milk bottles prepared for filling were also examined at these intervals. The total bacterial content of these bottles ranged from 700 to 6,200 bacteria, averaging 2,500 bacteria per bottle. Monthly examinations of specimens of butter and skim-milk powder were negative for viable *Mycobacterium tuberculosis* by animal inoculations. Throughout this period samples of the water in five 10 cubic centimeter amounts and all other ingredients in 0.01 gram or cubic centimeter amounts were negative for *Escherichia coli*.

Additional macroscopic colony counts were made of seventy-two samples of the finished product over a period of six months. The maximum count was 30,600, the minimum count 400, averaging slightly less than 6,000 per cubic centimeter.

TABLE 1.—*Bacteria per gram or cubic centimeter of the ingredients and of the finished reconstituted milk by months.*

Specimen.	First examination.		Second examination.		Third examination.	
	Plate count per g or cc.	Breed count per g or cc.	Plate count per g or cc.	Breed count per g or cc.	Plate count per g or cc.	Breed count per g or cc.
Milk powder	490,000	60,900,000	300,000	44,000,000	180,000	31,000,000
Butter	62,000	----------	110,000	----------	73,000	----------
Water	[a] 2,200	----------	93	----------	260	----------
Finished product	10,500	890,000	7,200	690,000	17,000	330,000

[a] The initial examination of the water, which showed 2,200 bacteria per cubic centimeter, led to a more-efficient method of filtration and a marked reduction in the plate count on subsequent examinations.

As shown in Table 1, the bacterial plate colony count of the butter and water were found to be low. The plate colony count of the skim-milk powder was higher than would seem desirable. Plate colony counts of skim-milk powder are not an index of the number of bacteria in the original milk but indicate the number that survived drying or subsequently contaminated the powder.

The Breed count of the skim-milk powder was excessively high, indicating a probable high bacterial content of the fluid skim-milk used for drying. The experiments of Supplee and Ashbaugh(4) show that by the Breed count approximately 50 per cent of the bacteria disappear in milk dried by the Just hot roller process, but the percentage of bacteria that disappear in milk dried by the spray process is not known.

It is accepted that the Breed count on fresh natural milk is usually about four times as great as the plate colony count. The Breed counts made on the reconstituted milk averaged fifty-five times the number found by the plate colony count, and the Breed counts made on the skim-milk powder averaged approximately one hundred forty times the number found by the plate colony count. This, in the latter case at least, is due to the large number of bacteria killed during the process of drying the skim milk.

To arrive at an approximate effect of pasteurization on the bacterial content of the milk mixture, an estimate was made of the probable plate colony count of the mixture before pasteurization based on the plate colony counts of the milk powder, butter, and water adjusted to the amount of each that would be present in 1 cubic centimeter of the mixture. This estimate was compared with the actual plate colony count of the finished reconstituted milk made from these same ingredients on the same

day. It was found that pasteurization, in two of the samples, reduced the theoretical number of viable bacteria to one-sixth, and in the third sample, the reduction was less than one-half. This difference may be explained as due either to temperature variation in pasteurization or by the presence of a greater proportion of bacteria thermostabile to the temperature used.

To determine the bacteriological and nitrogenous changes that take place in skim-milk powder as a result of storage, examinations were made of specimens from two original barrels and then portions of each specimen were stored in sterile, air-tight, glass jars at 45° F. Samples were removed and tested at intervals of two weeks for a period of two months and a final examination made at the end of five months.

TABLE 2.—*The nitrogenous and bacteriological changes in skim-milk powder in storage at 45° F.*

MILK POWDER, SPECIMEN A.

Date.	Plate count.	Breed count.	Total nitrogen.	Ammonia nitrogen.		Amino acid nitrogen.	
				In milk powder.	In total nitrogen.	In milk powder.	In total nitrogen.
1933	*Per gram.*	*Per gram.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Jan. 6	240,000	26,700,000	5.65	0.0208	0.368	0.240	4.25
Jan. 19	230,000	29,600,000	5.60	0.0311	0.555	0.273	4.88
Feb. 6	200,000	28,900,000	5.58	0.0267	0.478	0.302	5.41
Feb. 21	220,000	29,500,000	5.63	0.0276	0.490	0.267	4.74
Mar. 7	180,000	25,900,000	5.71	0.0315	0.551	0.308	5.39
June 6	93,000	23,300,000	5.59	0.0400	0.715	0.290	5.19

MILK POWDER, SPECIMEN B.

Jan. 6	190,000	30,000,000	5.63	0.0233	0.410	0.198	3.51
Jan. 19	140,000	31,400,000	5.55	0.0273	0.492	0.274	4.94
Feb. 6	17,000	27,500,000	5.56	0.0239	0.429	0.301	5.41
Feb. 2_1	20,000	31,200,000	5.57	0.0277	0.496	0.288	5.17
Mar. 7	16,000	28,700,000	5.61	0.0263	0.469	0.299	5.33
June 6	9,000	28,200,000	5.57	0.3100	0.556	0.304	5.45

The results obtained are shown in Table 2. The initial Breed count was high in both samples of skim-milk powder and remained approximately the same in subsequent determinations during the period of storage, due consideration being given to the known variability of counts made by the Breed method.

Plate counts made from specimen A showed a gradual decrease on successive examinations, the initial count being 240,000 per gram and the final count 93,000 per gram. In specimen B the

decrease was more pronounced, diminishing from the initial count of 190,000 to 9,000 per gram. The viable bacteria in specimen A were largely diplococci and staphylococci and in specimen B the predominating type was staphylococcus. As would be expected in a medium of low moisture content, plate colony counts of both specimens showed no active bacterial metabolism.

During the process of drying the bacterial content of the milk is markedly reduced, but the products of certain chemical changes in the fluid milk that have been brought about by the metabolism of great numbers of bacteria are not removed by drying. It is essential, therefore, that the milk used be produced and handled under sanitary conditions and that it be at least of the same standards required of milk for pasteurization.

CHEMICAL EXAMINATIONS

The physical changes that take place in skim-milk powder in storage are usually described as the development of a musty or a tallowy odor, a decreased solubility of the casein, and a darkening of the color. The chemical nature of these changes has not been conclusively determined, except that the tallowy odor is known to be brought about by the oxidation of the small amount of butter fat present. This can usually be confirmed by the Kreiss test.

Ferris(5) has discussed the nitrogenous substances found in milk and cream and states that it is the general opinion of dairy chemists that certain changes in these nitrogenous constituents begin at an early stage, probably from the action of enzymes and bacteria upon the proteins. The degree of this change depends principally upon the kind and amount of contamination and upon the temperature at which the product is held. Intermediary products of protein destruction are formed, the simplest of which are the amino acids. The more favorable the conditions for enzymic and bacterial activity, therefore, the greater should be the number of amino groups formed from the original protein.

Shrader et al.,(6) in their investigations of the sanitary quality of one hundred samples of commercial milk powders, state that there is a direct correlation between the ammonia nitrogen and the bacterial content, whereas the amino acids do not seem to bear such a relationship. They also state that ammonia constitutes the end nitrogenous product of bacterial metabolism and is therefore a truer measure of bacterial activity. From their findings they conclude that "excessive bacteria count before

manufacture is indicated by the presence of an approximately proportional content of ammoniacal products."

The work of Shrader did not include the length of time and method of storage of the samples tested and no reference has been found in the available literature as to the influence of these factors on the nitrogenous decomposition products in milk powder.

As it appeared probable that these factors would have an important bearing on the nitrogenous decomposition products, the two stored samples of milk powder, discussed in the bacteriological section, were subjected to chemical examinations [2] in parallel with the bacterial counts during the five months' storage period. The determinations made were of total nitrogen, of ammonia nitrogen, and of amino acid nitrogen.[3]

Total nitrogen was determined on dry powder by the Kjeldahl-Gunning-Arnold method.(7) For the ammonia nitrogen, an aqueous solution containing a given amount of the milk powder was rendered alkaline with magnesium oxide and the mixture was distilled under reduced pressure. This distillate was caught in a known volume of 0.1 *N* sulphuric acid, and the excess acid was titrated back with 0.1 *N* sodium hydroxide, using Congo red as an indicator. Amino acid nitrogen was determined by the formol titration method of Malfatti.(8) The method consists essentially of adding solid potassium oxalate and neutral formaldehyde solution to the watery solution of the milk powder, and titrating the acid reaction produced in the mixture with 0.1 *N* standard alkali using phenolphthalein as an indicator, the free ammonia nitrogen being subtracted from the total titration.

The results of the chemical examinations are recorded, together with the bacteriological findings, in Table 2.

At the end of the five months' storage period both samples of milk powder showed a moderate darkening of color and a decreased solubility. There was a faint musty odor to both samples but no suggestion of a tallowy odor, and in both samples the Kreiss test for oxidation of fat was negative. However, some of the other samples of skim-milk powder from different

[2] The nitrogen determinations were made by Dr. J. Marañon, of the Bureau of Science, Manila, to whom the writer acknowledges his indebtedness.

[3] *Fat and total solids.*—Chemical examination of twenty-seven samples of the reconstituted milk showed an average fat content of 3.52 per cent and total solids of 12.81 per cent by the Babcock methods.

shipments were slightly positive to the Kreiss test, although no tallowy odor could be detected.

The successive nitrogenous determinations made on the two powders while held in storage showed an increase of ammonia nitrogen, and in the specimen in which the viable bacteria were greatly reduced by storage there was a definite increase in the amino acid nitrogen. These evidences of proteolytic changes indicate the presence of organic catalysts, enzymic in character, but whether they are native to the skim-milk powder or are the result of the metabolism or breaking down of bacteria could not be ascertained. It is probable that the proteolytic changes vary with the types of bacteria present in skim-milk powder, and whether the bacteria are living or dead.

As the ammonia nitrogen increased in both samples with the time held in storage, the statement of Shrader et al., that an ammonia nitrogen determination is a chemical confirmation of the bacterial content of the fluid milk used before manufacture, should at least be qualified to include the length of time and conditions of storage of the milk powder.

BIOLOGICAL EXAMINATIONS

It is a recognized fact that raw milk contains the various known vitamins in proportions as they exist in the feed of the lactating animal. The vitamin content of the feed is influenced by the seasons of the year and whether or not it is fresh and green, or dried. Thus milk from any one source may vary greatly in the amounts of vitamins present at different times during the year. This is especially true of vitamin C, which has been found to be in greater concentration in the milk in summer when cows are on pasture.(9) The instability at times of vitamin C in milk that is heated to high temperatures precludes powdered milk as a reliable source of this vitamin. The use of fresh fruits and certain vegetables, such as tomatoes, obviates the deficiency of this vitamin in the usual dietary.

Although milk is an excellent source of calcium and phosphorus, cow's milk may be deficient in vitamin D, as shown by Frank et al., of the United States Public Health Service.(10) In investigating the growth-promoting property of heated and raw milk, they found a rickets case rate of 31.5 per thousand in the heated-milk group and one of 51.1 per thousand for the raw-milk group. They considered the smaller rate for the heated-milk group as probably due to the increased cod-liver oil intake

of this group. To prevent a possible deficiency of vitamin D, milk may be irradiated before or after drying to enhance its antirachitic properties. The possible slight decrease of vitamin A in the butter fat caused by irradiation would not be a factor in the irradiation of liquid or dried skim-milk.

Vegetable oils in general are notably deficient in vitamin A and should not, therefore, be used in place of butter in making fresh-milk substitutes. The vitamin A content of butter depends upon the type of feed of the lactating animal and upon the methods used in manufacturing and storing the butter.

Lately, vitamin B has been divided into at least two distinct entities, B (B_1) and G (B_2). The first, B (B_1), possesses antineuritic and growth-promoting properties and is considered as being thermolabile. In powdered milk this vitamin remains in varying degrees according to the reaction of the fluid milk and the temperature and methods used in drying. Vitamin G (B_2) is distinctly more stable at the temperatures and methods used in drying milk. It possesses growth-promoting properties and is also a preventive and cure of pellagralike symptoms in the rat.

As the two basic ingredients of reconstituted milk—skim-milk powder and butter—originate in such widely separated countries, biologic tests were carried out to determine the vitamin A, B (B_1), and G (B_2) value of the finished product.

Healthy rats weighing from 40 to 50 grams and from twenty-eight to thirty days old were used. The rats were of two types, albino, and black and white. They were bred in this laboratory from stock that had originally been imported from the United States.

In the vitamin A experiments the purified basal ration consisted of the following: Purified casein, 18 parts; dextrin, 60; Crisco, 8; salt mixture (McCollum's No. 185),(11) 4; agar-agar, 2; extract of tikitiki, 8.

In the vitamin B experiments the basal ration consisted of the following: Purified casein, 18 parts; dextrin, 62; butter, 8; Crisco, 6; salt mixture (McCollum's No. 185), 4; agar-agar, 2.

Both basal rations were irradiated at a distance of 30 inches for fifteen minutes by a quartz mercury vapor lamp to insure an adequate supply of vitamin D. To insure an adequate supply of vitamin G (B_2), four parts of autoclaved yeast were

added to the basal ration fed to part of the rats on the vitamin-B-free ration plus the reconstituted milk. The basal rations were replenished daily, and the containers cleaned and sterilized twice weekly.

The following method was used in purifying the casein: It was first washed in distilled water, drained and washed daily for seven days with distilled water acidulated with acetic acid. After being pressed and dried it was placed in a Buchner filter and washed with 80 per cent alcohol, followed by 95 per cent alcohol, partly dried, and extracted for five hours with 95 per cent alcohol using a reflux condenser. The casein was then dried in a hot-air oven and was ready for use after being ground to a fine powder.

The dextrin was prepared by autoclaving cornstarch in a weak solution of citric acid water. The dextrinized cornstarch was then air dried and worked into a coarse powder.

The dried baker's yeast was autoclaved at fifteen pounds' pressure for six hours.

The butter fat was obtained by melting fresh butter and allowing it to stratify. The supernatant oil was recovered by decanting it from the water and curd.

Vitamin A in the reconstituted milk.—Male rats were used, and when pronounced symptoms of xerophthalmia appeared accompanied by loss in weight, the irradiated vitamin-A-free diet was supplemented with 10 cubic centimeters of reconstituted milk daily. Within two weeks the xerophthalmia had disappeared and a good rate of growth was established. These rats were later used for breeding with rats used in vitamin B experiments (fig. 1).

Vitamins B (B_1) and G (B_2) in the reconstituted milk.—Female rats were used in these experiments as it has been stated that rats of this sex require a greater amount of vitamin B for normal growth.(12) When the weights of the rats had declined and neuritis had appeared, the irradiated vitamin-B-free diet was supplemented with 20 to 30 cubic centimeters of reconstituted milk daily. This amount was found to be sufficient to cure the neuritis and to promote a fair rate of growth.

The vitamin-B-free ration of two of the rats was supplemented with four parts of autoclaved yeast at the time of the addition of the reconstituted milk. The rapid increase in weight of this group of rats over the rats receiving their vitamins B

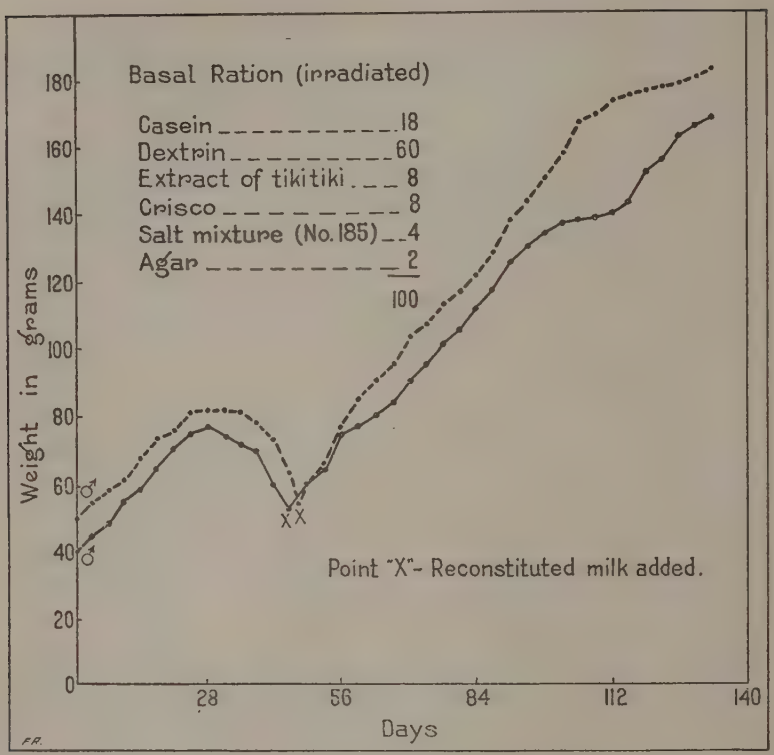


FIG. 1. Growth curve of two rats, showing the effect of adding 10 cubic centimeters of reconstituted milk daily to a vitamin-A-free basal diet. At the point X the rats had marked symptoms of xerophthalmia.

(B_1) and G (B_2) from the reconstituted milk alone indicates that, although milk when fed in the above-mentioned amounts contained sufficient B (B_1) to cure marked symptoms of neuritis and enough G (B_2) to promote a fair rate of growth, the amount of the latter factor was limited (figs. 2 and 3).

Two female rats, which were fed reconstituted milk in addition to the vitamin-B-free diet, and the two female rats fed the same diet plus autoclaved yeast were mated to the rats used in the vitamin-A tests. One female that did not receive yeast did not conceive. The others bore and reared normal litters.

SUMMARY

Studies were made of a reconstituted milk that is produced in Manila, Philippine Islands. This is prepared from skim-milk powder shipped from California and butter from Australia to

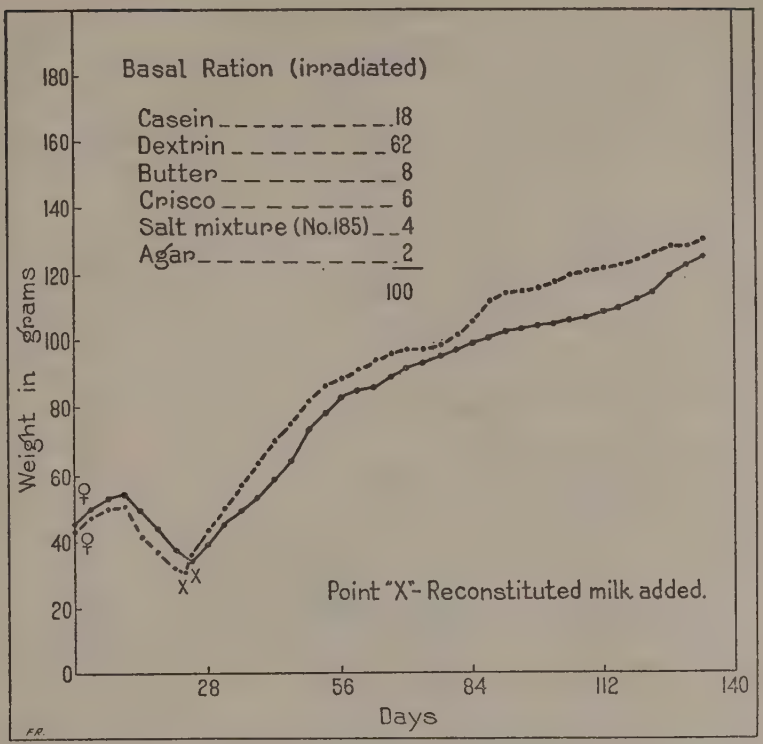


FIG. 2. Growth curve of two rats, showing the effect of adding 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

which is added water obtained from an artesian well on the premises of the reconstituting plant. The product is pasteurized in the reconstituting process and bottled in the usual manner for pasteurized whole milk. Bacteriological, chemical and biological examinations were carried out on the reconstituted milk and its ingredients.

The viable bacteria in the skim-milk powder, as determined by the plate count, was higher than would seem desirable although within the range of normal expectancy. The Breed counts of the skim-milk powder, while not higher than the average of available figures, would indicate that greater care should be taken in the production and handling of fluid milk used for drying. Plate colony counts of the butter and water were well within reasonable limits. Plate colony counts and total solids content, including fat, of the reconstituted milk show it to com-

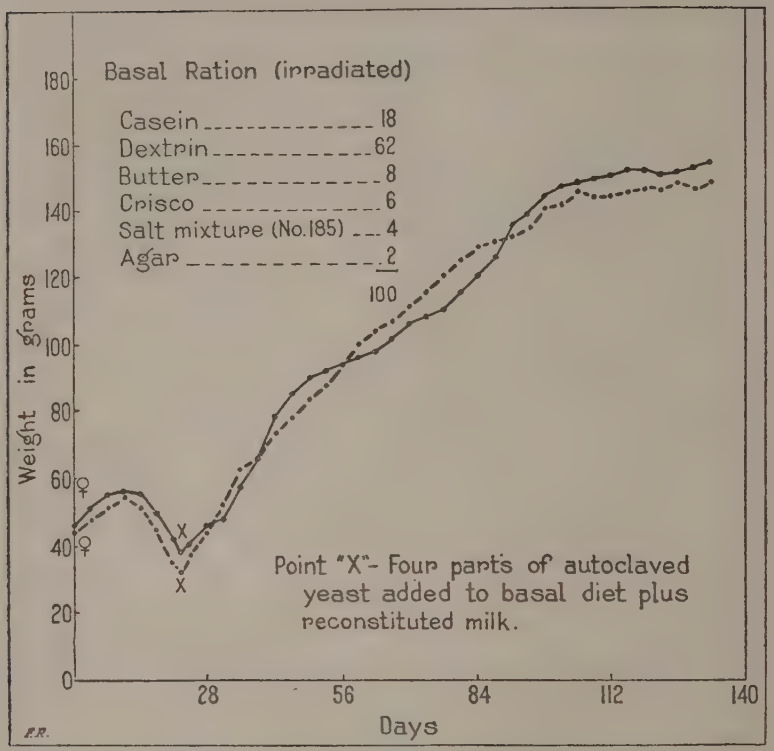


FIG. 3. Growth of two rats, showing the effect of adding four parts of autoclaved yeast and 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

ply, in these two particulars, with the prescribed limitations for Grade "A" pasteurized milk.

Animal inoculations of the skim-milk powder and butter were negative for viable *Mycobacterium tuberculosis*.

When held in storage for five months two samples of skim-milk powder, although showing a progressive decrease in viable bacteria, showed a progressive increase of ammonia nitrogen.

In the biological experiments conducted it was found that the reconstituted milk in daily amounts of 10 cubic centimeters contained sufficient vitamin A to cure rats with xerophthalmia and establish a good rate of growth. In daily amounts of from 20 to 30 cubic centimeters the milk was found to contain sufficient vitamins B (B_1) and G (B_2) to cure rats with marked neuritis and to promote a fair rate of growth.

CONCLUSION

When prepared in a properly equipped reconstituting plant, using standard ingredients, a fluid milk can be made from skim-milk powder, sweet (unsalted) butter, and water that will closely approximate pasteurized cow's milk.

BIBLIOGRAPHY

1. HUNZIKER, O. F. Condensed Milk and Milk Powder, 4th ed. La Grange, Ill. (1926).
2. American Public Health Association. Standard Methods of Water Analysis, 6th ed. New York, N. Y. (1925).
3. American Public Health Association. Standard Methods of Milk Analysis, 5th ed. New York, N. Y. (1928).
4. SUPPLEE, G. C., and V. J. ASHBAUGH. Bacteria counts of milk powder as obtained by the microscopic method. Journ. Dairy Sci. 5 (1922) 570.
5. FERRIS, L. W. A method for the determination of amino nitrogen and ammonia in cream and butter. Journ. Dairy Sci. 5 (1922) 399.
6. SHRADER, J. H., C. L. EWING, F. A. KORFF, and L. W. CONN. Sanitary quality of some commercial milk powders. Am. Journ. Hyg. 8 (1928) 387.
7. Association of Official Agriculture Chemists. Official and Tentative Methods of Analysis, 3d ed. Washington, D. C. (1930).
8. HAWK, P. B., and O. BERGEIM. Practical Physiological Chemistry, 9th ed. Philadelphia, Pa. (1927).
9. SCHWARTZE, E. W., E. J. MURPHY, and R. M. HANN. Studies on the destruction of vitamin C in the boiling of milk. Journ. Nutrition 2 (1930) 325.
10. FRANK, L. C., F. A. CLARK, W. H. HASKELL, M. M. MILLER, F. J. MOSS, and R. C. THOMAS. Growth promoting property of heated and raw milk compared. Public Health Reports 47 (1932) 1951.
11. MCCOLLUM, E. V., N. SIMMONDS, and J. E. BECKER. On a type of ophthalmia caused by unsatisfactory relations in the inorganic portion of the diet. Journ. Biol. Chem. 53 (1922) 313.
12. SHERMAN, H. C., and E. H. MACARTHUR. A quantitative study of the determination of vitamin B. Journ. Biol. Chem. 74 (1927) 107.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Growth curve of two rats, showing the effect of adding 10 cubic centimeters of reconstituted milk daily to a vitamin-A-free basal diet. At the point X the rats had marked symptoms of xerophthalmia.

2. Growth curve of two rats, showing the effect of adding 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

3. Growth curve of two rats, showing the effect of adding four parts of autoclaved yeast and 20 to 30 cubic centimeters of reconstituted milk daily to a vitamin B (B_1) and G (B_2) free basal diet. At the point X the rats had marked symptoms of neuritis.

A SCLEROTIUM SEED ROT AND SEEDLING STEM ROT OF MANGO [1]

By M. A. Palo

Junior Mycologist, Bureau of Science, Manila

TWELVE PLATES AND ONE TEXT FIGURE

In August, 1930, sclerotia of a soil-inhabiting fungus of the genus *Sclerotium* were found clinging to dead mango seedlings in a neglected nursery in Muntinlupa Plantation, Rizal Province, Luzon. The fungus appeared to be of little pathological significance, and was not investigated at the time. In the latter part of May, 1931, the nursery was cleaned and a few thousand mango seeds planted, the seedlings to be used for replacements in a new mango plantation. During the second half of June, following unusually wet weather, a severe outbreak of *Sclerotium* disease occurred on these plants. The sclerotia produced by the fungus appeared to be identical with those found in August, 1930, in the same nursery. Several of the seeds failed to germinate and many of the seedlings died. The disease progressed rapidly in July, as the seedbeds were always wet during this month of heavy precipitation.

The dead seedlings showed the white growth of mycelium and sclerotia of the causal fungus at the base of the stems and also on the surface of the soil around the plants. The rapid spread of the disease may have been occasioned by the movement of surface water during heavy rains or by the processes of cultivating, weeding, and watering the plants. By August, 10 per cent of the seedlings had died. The percentage of seeds that failed to germinate could not be ascertained, since there was no record of the number of seeds originally planted, but it is believed that the mortality was higher than in the case of the seedlings.

No *Sclerotium* disease on mango seedlings is reported from any country except the Philippine Islands. In a compiled list

[1] [2] The writer wishes to thank Dr. G. O. Ocfemia, Head of the Department of Plant Pathology, College of Agriculture, University of the Philippines, for reading the manuscript.

of hosts of *Sclerotium rolfsii* Sacc. made by Weber[8] for the United States and foreign countries in 1931, the mango is not included. In 1911, Wester[10] mentioned a species of *Sclerotium* associated with damping-off of mango seedlings in soil that had been kept too wet, but the disease was not studied. As it appears to be increasing in importance and tends to become a factor in the culture of mango seedlings in the nursery the present investigation was considered advisable.

DESCRIPTION OF THE DISEASE

The early indication of the disease is the development of a white mycelial weft on the stem at the ground level. Beneath the mycelial growth a dark brown lesion may be noted. In a severe infection, especially when the seedling is young or has newly emerged, the lesion may be seen in advance of the growing mycelium. While the disease progresses, the leaves begin to turn somewhat pale, but not markedly discolored, and wilt, after the mycelium has completely encircled the base of the stem (Plate 1, fig. 1). When young, rapidly growing seedlings are attacked, the succulent top droops or bends towards the ground because the tissues lose turgidity. Old seedlings killed by the disease stand erect. Under favorable conditions the fungus mycelium may be seen encircling the stem to a height of an inch or more above the ground level. In a little more advanced stage of the disease the sclerotia, which are white at first and brown with age, develop on the dead tissues and also on the surface of the soil upon which the mycelium has spread. Weather conditions unfavorable to the growth of the fungus, together with the hardening of the tissues of the growing seedlings, may hinder the progress of the disease, and if the infection is not severe the plant recovers and resists further infection. The seedlings that have recovered in this manner may show constrictions or cavities produced by the fungus on the tissues at the base of the stems.

In a few cases the newly-emerged seedlings may show signs of wilting without any evident lesion at the base. When such seedlings are pulled out the cotyledons may show an advanced stage of rotting due to the disease.

The seedlings severely attacked may die within a week after the infection becomes noticeable. The roots of the dead seed-

lings become soft and black, and the sclerotia of the causal fungus may be seen adhering to the cotyledons (Plate 2, fig. 1).

The disease also causes a severe rotting of the seeds in the beds before or during germination. Under favorable conditions the fungus on the dead seed may further develop and the mycelium may grow through the soil and produce numerous sclerotia on the surface over the dead seed (Plate 2, figs. 2 and 3).

CAUSAL ORGANISM

METHOD OF ISOLATION AND PREPARATION OF SUBCULTURES

Several sclerotia that were found associated with the decaying cotyledons of a diseased mango seedling were immersed in 1:1,000 mercuric chloride solution for thirty seconds, washed with three changes of sterile water; then each sclerotial body was plated out on sterile potato-glucose agar. Stock cultures were made by transferring the sclerotia that developed from a single colony. The cultures used in the subsequent studies, unless otherwise stated, were made by plating out a single sclerotial body obtained from the stock culture and then transferring, before the growth produced sclerotial bodies, blocks of the agar 3 millimeters square, containing the hyphæ of the fungus. The blocks were cut from the margin of the growth and placed upside down upon the agar so that the mycelium might have a direct contact with the fresh medium.

MORPHOLOGY

Mycelium.—When a sclerotial body is plated out on sterile agar medium it produces coarse white threads, which radiate in all directions from the sclerotium. The coarseness of the mycelial growth is due to the development of strands (Plate 3, fig. 1), which consist of a group of more or less parallel hyphæ that have grown closely together. The larger hyphæ develop at certain of the septa a clamp connection, opposite which a hyphal bud frequently arises and grows generally parallel to the main thread (Plate 3, fig. 3). Similar structures were reported by Higgins(1) in *Sclerotium rolfsii* Sacc. and by Welch,(9) Takahashi,(5) and Stevens(4) in *Sclerotium delphinii* Welch. A group of hyphæ of this kind may anastomose and grow closely together, developing into strands that impart coarseness to the growth. In certain plates of 25-day-old lactose-beef-agar and dextrose-beef-agar cultures, the

mango *Sclerotium* produced pinkish cinnamon [2] patches consisting of strands of short barrel-shaped cells (Plate 3, fig. 2) and hyphæ with knotlike structures (Plate 3, fig. 4). Also, on these two media the fungus under certain conditions developed mats of loosely interlaced lobulate hyphæ (Plate 3, fig. 5), which were perhaps special feeding structures of the fungus. As the sclerotia harden the mycelial growth is gradually depressed to the level of the medium. A comparison of the average measurements of the hyphæ of the mango *Sclerotium* with *Sclerotium rolfsii* Sacc. isolated from pepper, rice, and tomato, and with four strains of *Sclerotium delphinii* Welch (Table 1) showed no marked difference in their diameters.

TABLE 1.—*Comparative diameters of hyphæ of various races of Sclerotium from 3-day-old plate cultures on potato-glucose agar.*

Race.[a]	Diameter of hyphæ based on 100 measurements.	
	Range.	Average.
	Microns.	*Microns.*
Sclerotium on mango	1.70–10.00	4.60
Sclerotium rolfsii on pepper	1.60– 8.30	4.58
Sclerotium rolfsii on rice	1.50– 9.13	4.51
Sclerotium rolfsii on tomato	1.50– 8.35	4.60
Sclerotium delphinii W–517	1.40–10.50	4.60
Sclerotium delphinii I	1.60–10.50	4.70
Sclerotium delphinii II	1.68–11.20	4.60
Sclerotium delphinii III	1.40–10.50	4.80

[a] The cultures of *S. rolfsii* from pepper and rice were obtained from Mr. Gaudencio M. Reyes, assistant mycologist, and the one from tomato came from Dr. T. G. Fajardo, plant pathologist. The cultures of *S. delphinii* were obtained by Doctor Fajardo from the United States; *S. delphinii* labeled Wisconsin No. 517 from the plant pathology laboratory of the University of Wisconsin and *S. delphinii* I, *S. delphinii* II, and *S. delphinii* III from Dr. F. L. Stevens, of the University of Illinois.

Sclerotia.—The sclerotia herein described were those produced by the mango *Sclerotium* in plate cultures and in nature. In plate cultures the sclerotia first appear as white tufts of interlaced hyphæ on the surface of the fungous growth or at the ends of mycelial strands. Sometimes the sclerotia are formed first as enlarged white bodies on distinct stalks 1 to 5 millimeters in length. In a few plate cultures on potato-glucose agar numerous white tufts, some of which gave rise to the formation of stalk-bearing sclerotia, were noted to have developed (Plate

[2] The color nomenclature followed is that of Ridgway, Robert, Color Standards and Color Nomenclature. Washington, D. C. (1912).

4, fig. 1). However, many of these white tufts did not continue to develop into sclerotia and became inconspicuous with age. At first without a definite boundary, a sclerotial body later develops a cortical layer of hard colored tissue. The larger sclerotia exude droplets of clear liquid from several points on their surface (Plate 4, fig. 1). On media rich in food, such as steamed oatmeal, this exudate becomes amber-colored as the culture ages. The points of exudation are often marked by sunken spots or pits (Plate 4, fig. 2), which are usually round and distinct on larger sclerotia (Plate 5, fig. 3), but generally absent or inconspicuous on smaller ones.

On favorable media the sclerotia produced are very irregular in shape and size; some are subglobose, others elongate or nearly spheroidal, but on media lacking in nutriment they assume a globose form and tend to become uniform in size. The larger sclerotia are not only pitted but also often flattened and concave on the ventral sides (Plate 5, fig. 2). Hilumlike scars (Plate 5, fig. 1) may be found on the ventral portions of some sclerotia at points where they are attached to the mycelial columns or strands. The development of sclerotia may begin after six or seven days on very poor media and after eight or more days on media rich in food. As the sclerotia mature on potato-glucose agar, the surface color turns to ochraceous-buff, finally to Hay's brown or occasionally tawny. On other media, however, the color of the sclerotia may differ slightly in shade from those produced on potato-glucose agar. On nearly all media tried the fungus tends to unite the sclerotia into irregular aggregations 5 to 10 millimeters in extent. The production of similar masses of sclerotia is reported by Taubenhaus(7) and Edson and Shapovalov(1) in *S. rolfsii* and by Welch(9) in *S. delphinii.*

The sclerotia produced on potato-glucose agar vary in diameter from 0.9 to 3.8 millimeters, the greatest number falling under 2 millimeters. According to Table 4 the fungus produces larger sclerotia on media prepared from plant decoctions than on those containing animal protein. On steamed oatmeal and soil-cornmeal[3] the sclerotia were extremely variable in shape and size, being 0.9 to 12.5 millimeters on steamed oatmeal and 1.5 to 7.5 millimeters on soil-cornmeal.

A section of a mature sclerotial body produced in culture shows that it consists of pseudoparenchymatous tissues with

[3] One part by weight of cornmeal to 4 parts of soil.

intercellular cavities and inclosed by a hard, compact layer of colored cells (Plate 3, fig. 7). This layer may be from one to four cells thick. The composite sclerotia, which were sometimes produced on steamed oatmeal, appeared spongelike in texture (Plate 5, fig. 4), and when sectioned the tissue consisted of loose hyphal wefts (Plate 3, fig. 6), especially at points where the pits were markedly shown.

The sclerotia produced in nature are generally globular and smooth and are smaller and more uniform in size than those produced on artificial media. They develop either from the white tufts of intertwined hyphæ on the diseased tissues or laterally from the mycelial strands (Plate 12) that creep upon the surface of the soil from the lesion. Upon maturity they turn from white to either cacao brown or chocolate and vary in diameter from 0.6 to 1.6 millimeters.

The sclerotia germinate usually by the production of individual mycelial threads from points which come in contact with the medium. Sometimes the large pitted sclerotia send forth a dense fascicle of mycelium from the pits. In infection experiments in the greenhouse, many of the freshly matured pitted sclerotia, which were placed on very moist soil in pots, produced mycelial fascicles that bore new but smaller sclerotia after six to eight days.

Sporiferous stage.—No effort was made to induce the fungus to produce spores. As far as observed the mango *Sclerotium* produces spores neither in culture nor under field conditions, and will therefore be classed for the present as one of the members of the mycelia sterilia group of Fungi Imperfecti.

COMPARATIVE DEVELOPMENT OF THE MANGO SCLEROTIUM, S. ROLFSII AND S. DELPHINII, ON CERTAIN MEDIA

Eight strains of *Sclerotium* were used in this study, a single culture on a standard 100-millimeter Petri dish being prepared for each strain on each medium. A sufficient amount of the medium was used to make a layer about 6 millimeters thick in each plate. The cultures of each organism were made from a 3-day culture on potato-glucose agar by cutting out a 3-millimeter block of agar near the margin of the growth and transferring it to the culture dish. The cultures were incubated at room temperature (28° to 32° C.). The results of this study are given in Table 2.

TABLE 2.—*Showing the comparative rate and profuseness of growth and sclerotial production of eight races of Sclerotium on some common media.*

Culture medium and race of *Sclerotium*.	Average diameter of colonies after three days.	Profuseness and thickness of mycelial growth.[a]	Average number of sclerotia produced in each plate.	Diameter of sclerotia.
Potato-glucose agar:	*mm.*			*mm.*
Mango *Sclerotium*	71.0	+++	44	0.9– 3.7
S. delphinii W–517	66.0	+++	49	1.1– 4.1
S. delphinii I	66.5	+++	58	0.9– 4.0
S. delphinii II	63.0	+++	18	1.0– 5.5
S. delphinii III	48.5	+++	46	1.2– 4.5
S. rolfsii on pepper	63.9	+++	396	0.7– 1.6
S. rolfsii on rice	67.4	+++	575	0.7– 1.3
S. rolfsii on tomato	70.8	+++	678	0.7– 1.2
Carrot-glucose agar:				
Mango *Sclerotium*	57.0	+++	10	2.0– 3.7
S. delphinii W–517	61.0	++	10	2.2– 6.7
S. delphinii I	62.0	++	10	1.7– 5.4
S. delphinii II	58.0	++	7	1.4– 8.1
S. delphinii III	37.0	++	9	2.2– 4.8
S. rolfsii on pepper	67.5	+++	196	1.0– 2.3
S. rolfsii on rice	64.0	+++	275	0.8– 2.2
S. rolfsii on tomato	70.0	+++	291	0.8– 1.5
Oatmeal agar:				
Mango *Sclerotium*	55.0	+++	8	1.5– 3.0
S. delphinii W–517	60.0	++	4	1.5– 5.1
S. delphinii I	69.0	++	3	2.2– 4.3
S. delphinii II	60.0	++	2	2.1– 5.5
S. delphinii III	46.0	+	2	1.9– 4.1
S. rolfsii on pepper	73.1	+++	63	0.7– 1.4
S. rolfsii on rice	65.9	+++	113	0.6– 0.9
S. rolfsii on tomato	67.5	+++	144	0.6– 0.9
Cornmeal agar:				
Mango *Sclerotium*	54.5	+++	4	1.5– 4.1
S. delphinii W–517	59.0	++	6	1.4– 3.2
S. delphinii I	59.0	++	4	2.1– 3.5
S. delphinii II	53.0	++	2	2.3– 4.5
S. delphinii III	36.0	+	1	3.2– 3.7
S. rolfsii on pepper	59.5	+++	115	0.7– 1.6
S. rolfsii on rice	56.8	+++	198	0.8– 1.4
S. rolfsii on tomato	58.6	+++	241	0.8– 1.5
Dextrose-beef agar:				
Mango *Sclerotium*	57.0	+++	19	1.0– 3.0
S. delphinii W–517	49.4	++	8	0.9– 3.1
S. delphinii I	55.6	++	12	1.2– 4.5
S. delphinii II	51.8	++	3	1.2– 3.5
S. delphinii III	20.8	+	7	1.0– 2.6
S. rolfsii on pepper	60.5	+++	587	0.6– 1.0
S. rolfsii on rice	63.0	+++	784	0.6– 1.0
S. rolfsii on tomato	62.6	+++	874	0.5– 0.9

[a] Meaning of symbols: +, Scant growth; ++, moderate; +++, abundant; ++++, very abundant.

TABLE 2.—*Showing the comparative rate and profuseness of growth and sclerotial production of eight races of Sclerotium on some common media*—Continued.

Culture medium and race of *Sclerotium*.	Average diameter of colonies after three days.	Profuseness and thickness of mycelial growth.[a]	Average number of sclerotia produced in each plate.	Diameter of sclerotia.
Saccharose-beef agar:	*mm.*			*mm.*
Mango *Sclerotium*	52.0	+++	26	1.1– 3.2
S. delphinii W–517	52.0	++	16	1.0–.3.3
S. delphinii I	55.0	++	25	1.2– 4.3
S. delphinii II	50.0	++	9	1.0– 3.5
S. delphinii III	28.0	+	4	1.9– 3.0
S. rolfsii on pepper	54.5	+++	133	0.8– 1.5
S. rolfsii on rice	51.1	+++	387	0.5– 1.3
S. rolfsii on tomato	51.0	+++	354	0.5– 1.2
Steamed oatmeal:				
Mango *Sclerotium*	56.0	++++	114	[b] 1.0–12.5
S. delphinii W–517	45.5	++++	85	1.6– 6.0
S. delphinii I	45.0	++++	383	1.9– 6.4
S. delphinii II	47.5	++++	59	2.2– 7.5
S. delphinii III	27.5	++++	28	1.3– 4.6
S. rolfsii on pepper	47.3	++++	3,913	0.7– 2.4
S. rolfsii on rice	49.1	++++	6,352	0.7– 2.0
S. rolfsii on tomato	59.6	++++	6,405	0.7– 2.2
Steamed cornmeal:				
Mango *Sclerotium*	59.5	++++	101	1.2– 4.5
S. delphinii W–517	51.0	++++	66	1.2– 8.2
S. delphinii I	48.7	++++	162	2.2– 4.6
S. delphinii II	56.7	++++	63	2.8– 9.2
S. delphinii III	26.6	++++	26	1.3– 5.6
S. rolfsii on pepper	60.9	++++	2,369	0.7– 2.5
S. rolfsii on rice	62.2	++++	2,825	0.7– 2.4
S. rolfsii on tomato	64.3	++++	3,065	0.7– 2.6

[a] Meaning of symbols: +, Scant growth; ++, moderate; +++, abundant; ++++, very abundant.

[b] The measurements indicated here include the composite sclerotia that were spongelike in texture.

In the character of mycelial growth no significant differences were noted among the races of *Sclerotium* used in this study. The slight differences observed in the profuseness and rate of growth were not sufficient to distinguish one strain from another. According to Table 2 *S. delphinii* III has the distinction of growing less rapidly than any other strain on all media. During the first three days of growth of the mango *Sclerotium* the mycelium showed characteristics similar to those of *S. delphinii* I, *S. delphinii* II, and *S. delphinii* W–517, but as the culture aged the growth became thick and floccose like that of

S. rolfsii. The growth of *S. delphinii* III was conspicuously dendritic, especially on carrot-glucose agar. Upon maturity of the sclerotia, the mycelial growth of all the strains growing on agar media became inconspicuous but this occurred much sooner in *S. delphinii* strains than in the mango *Sclerotium* and *S. rolfsii.*

Some differences were noted in the length of time necessary for the sclerotia to begin to develop. The mango *Sclerotium* produced sclerotia after eight or more days on agar media, while *S. rolfsii* and *S. delphinii* strains produced them after four to five days; in the case of *S. delphinii* III, owing perhaps to its slower growth than any other strain of *S. delphinii,* six to seven days were required. Sclerotial production by all cultures began much later on nutritive media, such as steamed oatmeal, than on agar media because the vegetative growth could go on longer.

The most striking difference between *S. rolfsii* and either mango *Sclerotium* or *S. delphinii* was in the size and number of sclerotia produced; those of the mango *Sclerotium* and *S. delphinii* strains were conspicuously larger and less numerous than those of *S. rolfsii.* The sclerotia of *S. rolfsii* are cinnamon brown or olive brown, smooth, generally globose and nearly uniform in size; those of the mango *Sclerotium* and *S. delphinii* are Hay's brown or tawny, surface-marked, concave or flattened on the ventral sides, and extremely variable or irregular in shape and size.

As shown in Table 2 the sclerotia of the mango *Sclerotium* and *S. delphinii* strains are not only larger but also of very much wider range of variation than those of *S. rolfsii.* On potato-glucose agar the sclerotia produced by each strain in a number of culture dishes were collected and then the diameters of 200 sclerotia were measured by calipers and arranged in classes varying by 0.1 millimeter. The results of these measurements, with the exception of those of pepper and tomato strains of *S. rolfsii,* are shown in fig. 1. The greater number of sclerotia fell in the diameter class 2.0 to 2.5 millimeters in *S. delphinii* strains; 1.7 to 2.4 millimeters in the mango *Sclerotium;* and 0.9 to 1.1 millimeters in the rice strain of *S. rolfsii.* With the strains of *S. rolfsii* not represented in fig. 1 they fell between 1.0 and 1.2 millimeters in the pepper strain and between 0.8 and 1.0 millimeter in the rice strain.

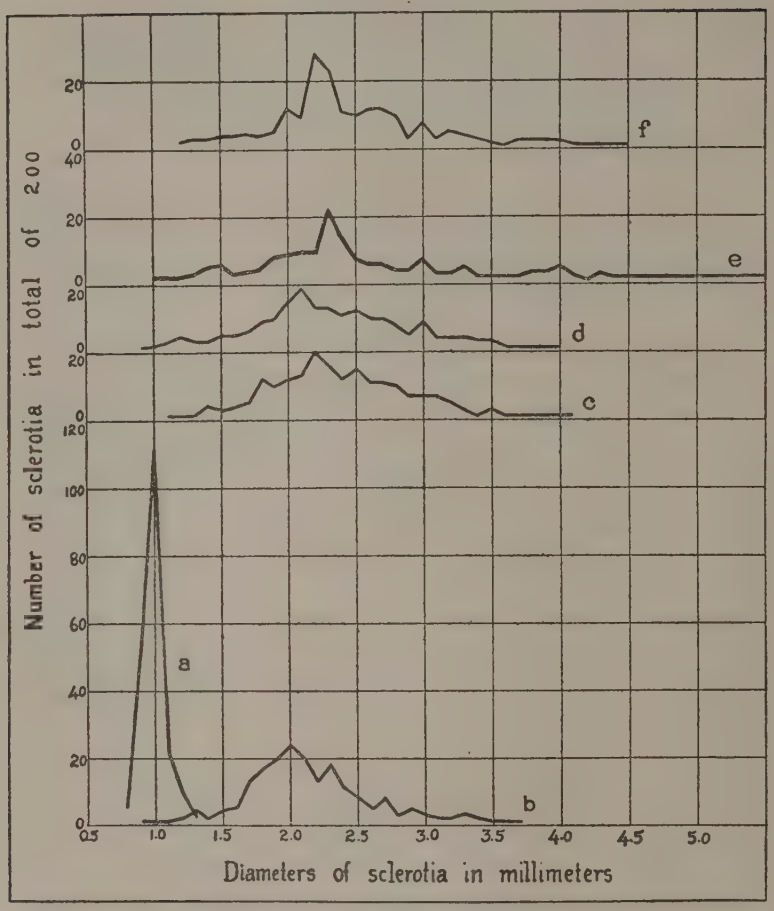


FIG. 1. Graphs showing sclerotial size of six strains of *Sclerotium* obtained from plate cultures on potato-glucose agar. *a*, *Sclerotium rolfsii* on rice; *b*, *Sclerotium* on mango; *c*, *Sclerotium delphinii* W-517; *d*, *Sclerotium delphinii* I; *e*, *Sclerotium delphinii* II; *f*, *Sclerotium delphinii* III.

COMPARATIVE RATE OF GROWTH AND PRODUCTION OF SCLEROTIA OF MANGO SCLEROTIUM, S. DELPHINII, AND S. ROLFSII AT DIFFERENT TEMPERATURES

In these studies seven strains of *Sclerotium* were used; namely, *Sclerotium* on mango, *S. rolfsii* on rice, *S. rolfsii* on tomato, *S. delphinii* W–517, *S. delphinii* I, *S. delphinii* II, and *S. delphinii* III. At each temperature eight standard Petri dishes, containing about 18 cubic centimeters of potato-glucose agar, were used for each strain. A mature fresh sclerotium, obtained from the plate cultures of each strain on potato-glucose agar, which had

been incubated at room temperature, was transferred to the middle of each dish, and the cultures were distributed to four incubation chambers that were maintained at temperatures of 35° to 35.5° C., 28° to 32° C. (room temperature), 19° to 20° C., and 6° to 8° C., respectively, for twenty days. Incubators adjusted to cover the entire range of growth were not available. The results of these studies are given in Table 3 and shown in Plates 6 and 7. In Plate 6 only *S. rolfsii* on rice, the mango *Sclerotium,* and *S. delphinii* I are represented; in Plate 7 all are represented except *S. rolfsii* on tomato.

TABLE 3.—*Showing the average diameter of eight colonies each of the seven races of Sclerotium grown at different temperatures for four days in plates of potato-glucose agar.*

Race.	35° to 35.5° C.	28° to 32° C. (room temperature).	19° to 20° C.	6° to 8° C.
	mm.	*mm.*	*mm.*	*mm.*
Sclerotium on mango	6.6	90.0	39.0	0
Sclerotium rolfsii on rice	24.0	88.0	9.0	0
Sclerotium rolfsii on tomato	26.0	87.0	8.0	0
Sclerotium delphinii W–517	5.5	86.7	20.6	0
Sclerotium delphinii I	6.6	88.0	23.5	0
Sclerotium delphinii II	6.2	78.7	22.5	0
Sclerotium delphinii III	5.5	62.2	18.5	0

It may be seen in Table 3 that the most vigorous growth of all the strains occurred at room temperature (28° to 32° C.), at which no significant difference in the rate of growth of any strain was noted, with the exception of the less rapid growth of *S. delphinii* III. A little difference was noted in the time necessary for the sclerotia to begin development. The rice and tomato strains of *S. rolfsii, S. delphinii* W–517, *S. delphinii* I, and *S. delphinii* II produced sclerotia after four to five days; *S. delphinii* III, after six to seven days; mango *Sclerotium,* after eight to ten or more days. The production of numerous sclerotia distinguished the strains of *S. rolfsii* from the strains of *S. delphinii* and the mango *Sclerotium.* In general the mango *Sclerotium* and strains of *S. delphinii* produced less than one-tenth as many sclerotia as *S. rolfsii.*

At 35° to 35.5° C. the mango *Sclerotium* and strains of *S. delphinii* did not germinate as readily as the rice and tomato strains of *S. rolfsii,* since germination became apparent about twenty-four or more hours after the strains of *S. rolfsii* had

shown visible growth. The subsequent development was very slow and before the fungous growth reached 10 millimeters in diameter the cultures ceased to grow. When a few plates of each strain were removed and subjected to room temperature, the growth started anew and covered the surface of the plates after four days. This indicates that this temperature is unfavorable to the growth of the fungus and perhaps, after prolonged exposure, fatal to the growth of the mango *Sclerotium* and *S. delphinii* strains. The critical temperature for these fungi, therefore, must be a little higher than 35.5° C. On the other hand, the strains of *S. rolfsii,* although slightly affected in growth, continued to develop until, after six days, they produced sclerotia that showed much wider variability in size than those produced by the same strains at room temperature.

At 19° to 20° C. the mango *Sclerotium* showed more vigorous growth than any of the strains of *S. delphinii,* while the rice and tomato strains of *S. rolfsii* showed less rapid growth. The sclerotia produced (Plate 7) by all the strains appeared to be slightly smaller, but less variable in size, than those produced at room temperature. Actual counts showed that the mango *Sclerotium, S. delphinii* W–517, *S. delphinii* I, and *S. delphinii* II had produced on the average more sclerotia at this temperature than at room temperature.

At 6° to 8° C. no germination of any of the strains occurred, but the sclerotia were not killed by the twenty days' exposure, since germination occurred after twelve hours when the plates were removed and placed at room temperature.

It may be seen from the above that the mango *Sclerotium* is in closer agreement with *S. delphinii* than with *S. rolfsii* with respect to temperature relations. The strains of *S. rolfsii* are markedly different from the mango *Sclerotium* and from strains of *S. delphinii* in that they showed better development at higher temperatures but less growth at lower temperatures.

THE SCLEROTIUM ISOLATED FROM MANGO IS A DISTINCT RACE OF SCLEROTIUM

In his studies of the phenomenon of aversion in *S. rolfsii,* Nakata(4) reports that when transfers from two different strains of this species are planted side by side in the same plate the growths stop at points where the mycelium from the two sources nearly meet, leaving a narrow region of the medium free from hyphæ. According to this author the submerged hyphæ at the clear regions show plasmolysis and then disintegration, while the aërial mycelia become fine and slender and curl back-

ward. Likewise, Stevens(5) states that when any two of the races of *Sclerotium delphinii* Welch were planted upon cornmeal agar in a single Petri dish, a band extending across the plate was formed at the line of junction of the two colonies and "when any races were grown against another colony of the same race the mycelium of the two colonies mingled freely and no abnormal branching resulted." Following the studies made by Nakata and Stevens, two mature sclerotia of mango *Sclerotium* were inoculated upon one side of a Petri dish containing potato-glucose agar and another two mature sclerotia of *S. rolfsii* upon the opposite side of the plate. An aversion took place between the colonies (Plate 8, figs. 1, 2, and 3) obtained from any two cultures used. In rare cases, however, more sclerotia were formed at the free region than in other places in the plate. Along the junction line the hyphæ from the colonies of the mango organism became slightly discolored. Subsequently these colored hyphæ crept over the free space and then ceased to grow when they touched the hyphæ from the neighboring transfer. Aversion took place also when any two strains of *S. rolfsii* were allowed to grow on the same medium in a single Petri dish (Plate 8, figs. 4, 5, and 6).

The above study was repeated using *S. delphinii* W–517, *S. delphinii* I, *S. delphinii* II, *S. delphinii* III, and the mango *Sclerotium* in plates containing cornmeal agar. A band extended across each plate between the growths of a strain of *S. delphinii* and the mango *Sclerotium* (Plate 9). There was no evidence of antagonism between the growths that developed from the sclerotia from the same culture as shown by the absence of the fungus-free band on the media. It was also noted that although the growth of the mango *Sclerotium* on cornmeal agar was more luxuriant than that of any of the strains of *S. delphinii* it showed after eight days only incipient formations of sclerotia, while each strain of *S. delphinii* had developed a number of them. The mango *Sclerotium* may produce either sclerotia or white sterile loose lumps of hyphæ where its mycelium comes in contact with the hyphæ from a strain of *S. delphinii.* These characteristics are not exhibited when two or more transfers of the mango *Sclerotium* are planted in the same culture dish. On the other hand a strain of *S. delphinii* produced scattered sclerotia and did not develop white loose lumps of hyphæ where its growth came in contact with the growth of the mango *Sclerotium.* From the results of this experiment it seems that all of the strains of *S. delphinii* exerted some repellant or antago-

nistic effect on the mango *Sclerotium.* According to Stevens(5) if antagonism occurs between fungous growths it indicates a difference between the strains. This antagonism does not appear when like strains are planted together in a culture dish. Nakata(3) states that "when aversion occurs it is to be concluded that the inocula in question are of different strains but when it does not, that they are of the same strain." From experiments to determine the relation of the mango *Sclerotium* to known strains of *S. delphinii* the writer found that the mango *Sclerotium* is a strain distinct from the four known races used for comparison. This conclusion is based on the fact that antagonism or aversion occurred when the mango *Sclerotium* was grown with different strains of *S. delphinii.*

TAXONOMY

In the foregoing morphological and cultural studies the mango *Sclerotium* appears to resemble more closely *S. delphinii* than *S. rolfsii.* The difference found between the mango *Sclerotium* and *S. rolfsii* seems sufficiently great to warrant the separation of the mango fungus from the latter species. The characters by which the mango organism may be readily separable from any of the strains of *S. rolfsii* used in these studies are summarized as follows: (*a*) Sclerotial production on agar media almost always began after four to five days in *S. rolfsii* and after eight to ten days in the mango *Sclerotium;* (*b*) the development of concave or flattened sclerotia and sclerotial bodies with hilum-like scars separates the mango fungus from *S. rolfsii,* which produces globose sclerotia; (*c*) pits on the sclerotia were distinct in the mango organism but were generally absent in *S. rolfsii;* (*d*) the production of conspicuously larger, more irregular, but less numerous sclerotia, Hay's brown or tawny in color, distinguished the mango *Sclerotium* from *S. rolfsii,* which developed small, numerous, and more uniform sclerotia of cinnamon brown color; (*e*) at 35° to 35.5° C. the cultures of *S. rolfsii* showed better development and production of sclerotia, while the mango *Sclerotium* showed arrested growth and no production of sclerotia.

There were also minor differences noted between the mango *Sclerotium* and *S. delphinii.* The mango fungus produced in general densely floccose mycelium, but the growth of *S. delphinii* was in the form of strands of white mycelium. *Sclerotium delphinii* began to produce sclerotia in plate cultures on agar media after four to five days, except in the case of *S. delphinii* III

which produced them usually after six to seven days, but the mango *Sclerotium* produced these bodies only after eight to ten or more days. The sclerotia of *S. delphinii* are on the average larger than those of the mango *Sclerotium,* as shown in Table 4. However, there are certain media and conditions in which these differences in average size become less significant. Since the characters of the mango *Sclerotium* resemble more nearly those of *S. delphinii* than those of *S. rolfsii,* the writer refers the mango organism to *Sclerotium delphinii* Welch.

TABLE 4.—*Showing the average diameters of sclerotia of mango Sclerotium and S. delphinii strains on six agar media.*

Medium.	Mango *Sclerotium.*	*S. delphinii* W-517.	*S. delphinii* I.	*S. delphinii* II.	*S. delphinii* III.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Potato-glucose agar	2.2	2.4	2.3	2.8	2.6
Carrot-glucose agar	2.7	3.9	3.4	4.4	3.2
Oatmeal agar	2.2	3.2	2.9	3.9	2.9
Cornmeal agar	2.3	2.4	2.6	3.4	3.5
Saccharose-beef agar	1.7	1.8	2.0	1.9	1.8
Dextrose-beef agar	1.7	1.9	2.4	2.2	1.7

For purposes of verification, cultures of the mango fungus were sent to Dr. F. L. Stevens, of the University of Illinois, and in his letter dated October 27, 1932, to Dr. T. G. Fajardo, of the botany division of the Bureau of Science, he states, "I would incline to agree with Mr. Palo and refer the fungus to *S. delphinii.*"

PATHOGENICITY OF THE FUNGUS

Infection with the mycelium.—The shells of fresh mango seeds were removed and the seeds planted in pots containing moist soil that had been autoclaved for three hours at 15-pounds' pressure. After twelve to seventeen days the young plants all emerged and were immediately inoculated with the fungus from young plate culture on potato-glucose agar by placing a block of the agar, containing the mycelium, at the base of each plant. The mycelium developed rapidly and produced small sclerotia of more or less uniform size on the surface of the soil two or three days after inoculation, within which period nearly all the inoculated plants showed visible symptoms of infection. In some instances the dark brown lesion, which is the characteristic symptom of the disease in nature, was noticeable after twenty-four hours. Seventeen of the twenty inoculated plants died

within twenty-three days after inoculation. Owing to the rapid development of the disease many of the inoculated plants did not show any marked change in the color of the leaves. As soon as the dark brown lesion appeared and the mycelium had grown around the base of the stem and caused the tissues of the young plants to shrivel, the leaves showed signs of wilting (Plate 10, fig. 2). Subsequently the affected plant drooped and died. A few of the wilted seedlings were dug up and these showed the sclerotia on the base of the stems and also on the cotyledons (Plate 11, fig. 2). The rest of the inoculated seedlings that remained alive showed at first the dark brown lesion at their bases but no further development of the disease was noted. These survived. All of the thirteen plants used as checks remained healthy.

Infection by burying the seed with sclerotia.—Fresh mango seeds from which the husk was removed, together with a few mature sclerotia obtained from a 20-day-old plate culture of the fungus on potato-glucose agar, were planted to a depth of 1 inch in sterilized soil. Ten pots were used, with one seed to a pot. Three other pots to which no sclerotia were added were used as checks. The seeds in all the control pots and in seven of the ten inoculated pots germinated after twelve to fifteen days. The seedlings in three of the inoculated pots died, and sclerotia were found at the base ten days after emergence. Two other inoculated plants showed the symptoms of the disease but continued to live. The remainder of the seedlings in the inoculated pots did not show any sign of infection. The seeds that did not germinate in the inoculated pots were dug up and examined. All were rotted, and several sclerotia adhered to the decayed cotyledons. The check plants remained healthy.

Infection by planting the seed in natural Sclerotium-infected soil.—A quantity of soil naturally infected with mango *Sclerotium* was obtained from one of the beds in which the disease occurred severely in Muntinlupa Plantation, Rizal Province. The soil contained mycelium and sclerotial bodies of the fungus. Five hundred grams of this soil were added to each of ten pots containing sterilized soil and then mixed thoroughly. A fresh mango seed with its husk removed was planted in each pot. The control consisted of four pots to which infected soil was not added. All the seeds germinated but only five of the newly emerged plants in the infected soil showed the disease. After a few more days three of the diseased seedlings showed signs of

wilting and later died; the other two infected ones survived. The rest of the seedlings in the inoculated pots, as well as all of the control plants, remained disease-free.

In all of the above infection experiments the organism was recovered in reisolations made by plating out the sclerotia on potato-glucose agar. It may be noted in the above tests that the disease can readily be reproduced on mango seedlings by planting the seeds in soil naturally infected with *Sclerotium*, or by placing close to the seeds at time of planting, or close to the seedlings after their emergence, either mycelium or sclerotial bodies. The fungus under study showed pronounced virulence on young or newly emerged plants but it lost its power of killing the seedlings as soon as they developed harder tissues. Its potential parasitism has been proved on mango seedlings without inflicting injuries at points of inoculation.

INOCULATION OF VARIOUS PLANTS WITH THE MANGO SCLEROTIUM

The pathogenicity of the mango *Sclerotium* was tested on various plants by placing a square centimeter block of agar containing the mycelium of a young culture of the fungus at the base of each plant. As shown in Table 5 positive infection was obtained on nearly all the inoculated plants and in many cases the plants died of this infection. A marked virulence was shown by the fungus on mango (*Mangifera indica* L.), paayap [*Vigna sinensis* (L.) Savi], upo [*Lagenaria leucantha* (Duch.) Rusby], patola [*Luffa acutangula* (L.) Roxb.], squash (*Cucurbita maxima* Duch.), pepper (*Capsicum annuum* L.), eggplant (*Solanum melongena* L.), radish (*Raphanus sativus* L.), and cabbage (*Brassica oleracea* L.).

The other crops were also found susceptible but they were attacked less severely by the fungus. Frequently the infected plants that continued to live showed cavities or shriveled-up tissues at points where the fungus first became established. The period of incubation, in most cases, ranged from one to four days. It seems possible that the hosts, which were attacked severely by the mango fungus in inoculation experiments in the greenhouse, will also become infected under natural conditions and will therefore serve as agents in harboring the pathogene. Since the above experiments were not conducted extensively with other hosts, further observation and experiments may increase the number of plants known to be affected by the fungus.

TABLE 5.—*Showing the results of inoculating various plants with mango Sclerotium ten days after inoculation.*

Common name of plant.	Botanical name.	Age of plants.	Plants used.		Plants infected.		Plants killed.	
			Inoculated.	Check.	Inoculated.	Check.	Inoculated.	Check.
		Days.						
Ampalaya	*Momordica charantia* L.	25	6	4	6	0	0	0
Bean	*Phaseolus vulgaris* L.	15	6	5	6	0	0	0
Cabbage	*Brassica oleracea* L. var. *capitata* L.	30	6	6	6	0	6	0
Carrot	*Daucus carota* L.	30	5	4	3	0	3	0
Corn	*Zea mays* L.	15	7	6	2	0	0	0
Cucumber	*Cucumis sativus* L.	29	6	5	6	0	3	0
Eggplant	*Solanum melongena* L.	30	6	4	6	0	6	0
Garlic	*Allium sativum* L.	32	5	5	5	0	0	0
Mandarin orange	*Citrus nobilis* var. *deliciosa* Swingle	31	18	15	8	0	6	0
Mungo	*Phaseolus radiatus* L.	15	10	13	10	0	10	0
Mustard	*Brassica integrifolia* (West) O. E. Schulz	35	4	3	4	0	2	0
Onion	*Allium cepa* L.	32	5	5	5	0	3	0
Paayap	*Vigna sinensis* (L.) Savi	15	13	12	13	0	3	0
Papaya	*Carica papaya* L.	35	4	4	4	0	1	0
Patola	*Luffa acutangula* (L.) Roxb	15	6	7	6	0	3	0
Peanut	*Arachis hypogaea* L.	20	9	7	4	0	0	0
Pepper	*Capsicum annuum* L.	35	4	4	2	0	2	0
Radish	*Raphanus sativus* I.	35	4	3	4	0	4	0
Rice	*Oryza sativa* L.	30	25	30	20	0	0	0
Sitao	*Vigna sesquipedalis* Fruw.	15	3	2	3	0	0	0
Squash	*Cucurbita maxima* Duch.	15	4	4	4	0	2	0
Sweet potato	*Ipomoea batatas* (L.) Poir.	32	6	4	1	0	0	0
Tomato	*Lycopersicum esculentum* Mill.	35	20	35	20	0	20	0
Upo	*Lagenaria leucantha* (Duch.) Rusby	15	5	7	5	0	3	0

A COMPARISON OF THE INFECTIVE CAPACITY OF THE MANGO SCLEROTIUM AND SCLEROTIUM ROLFSII FROM PEPPER, RICE, AND TOMATO

Young seedlings of mango (*Mangifera indica* L.), papaya (*Carica papaya* L.), cabbage (*Brassica oleracea* L. var. *capitata* L.), radish (*Raphanus sativus* L.), tomato [*Lycopersicum esculentum* Mill.), mustard [*Brassica integrifolia* (West) O. E. Schulz.], ampalaya (*Momordica charantia* L.), and rice (*Oryza sativa* L.) were inoculated under identical conditions with the mango *Sclerotium*, and with *S. rolfsii* from pepper, rice, and tomato in separate pots. Infection was obtained on all hosts inoculated with each of the strains, and the disease progressed with almost equal severity on those hosts. From this limited trial it was found that under conditions used in artificial experiments the mango organism is as aggressive as *S. rolfsii.*

SEASONAL DEVELOPMENT

The *Sclerotium* disease on mango seedlings occurred in the nursery in Muntinlupa Plantation, Rizal Province, from June to October, 1931; it was especially prevalent in July and August when the precipitation was rather heavy and when the seedlings were still young and in their most susceptible stage. Since mango seeds can hardly be kept viable for more than a week, they are planted while still fresh; and since they can be obtained in greater abundance in June and July than in other months, planting usually takes place in these months, during which the conditions are favorable for the development of the disease. In the presence of conditions favorable for infection, the seeds planted in beds containing the fungus would produce some seedlings that would show the disease. Moisture is undoubtedly the most important factor influencing development of the fungus in seedbeds, so in months of heavy precipitation the disease is prevalent. Under moist conditions the fungus is capable of living as a saprophyte in the soil. In October and November, 1931, the disease was found also on a few mature seedlings left in the nursery, but its development was so slow that it did not affect them seriously. In December, 1931, and January, 1932, certain parts of the beds were overcome by the thick growth of grasses and weeds, which kept the soil beneath them always more or less moist, thus supplying favorable conditions for the growth and survival of the fungus. During the dry months (January to April) the fungus seems to be less destructive, especially if the temperature is rather high.

VIABILITY OF THE SCLEROTIA

That the fungus can live over an unfavorable season and then develop by means of sclerotia is evidenced by the following test: A quantity of soil with an abundance of sclerotia was air-dried and then kept in a Petri dish at room temperature. From time to time some sclerotia were picked out with flamed forceps, washed with several changes of sterile water, and plated out on potato-glucose agar. Growth was readily obtained after six months, and after thirteen months a few of the sclerotia were still alive. That soils saturated with water do not seem to affect the germination of sclerotia and the virulence of the fungus much was shown by the following test: Each of nine pots containing sterile soil was planted with a husked, clean, fresh mango seed. After the emergence of the seedlings, six pots were inoculated with mature sclerotia, and the other pots were used as checks. All of the pots were placed in a shallow, rectangular, galvanized-iron pan filled with water. The top layer of the soil in the pots was kept always very moist. Sclerotia germinated on the surface of the soil after six to eight days and later caused a severe infection in the mango seedlings. From this test it seems probable that under moist conditions of the soil in the nursery the fungus will live indefinitely, especially if susceptible hosts are present.

DISCUSSION AND SUGGESTIONS FOR CONTROL

In the absence of experiments on the control of the *Sclerotium* causing seed rot and seedling stem rot of mango in the nursery the following may be suggested:

1. *Sanitary measures.*—Strict sanitation, if practiced, will reduce to a great extent the destruction caused by the disease, since the sclerotia are not as numerous as spores and are not adapted to wind dissemination. The soils infected by the fungus should be thoroughly surface-burned before the seedbeds are prepared. This process will kill all the plant pathogenic organisms hibernating or growing saprophytically in the soil. In places where combustible materials are readily available it can be done with little expense. Infected mango seedlings and weeds should be pulled up and burned.

2. *Cultural methods.*—As the fungus is a moisture-loving organism, there should be no excessive use of water or close planting. The latter is conducive to poor aëration, tends to increase the humidity, and induces the rapid spread of the fungus from plant to plant. The seedbeds should be provided with

ample drainage, and it is advisable to prepare them in a place that is not too shady. In the nursery in Muntinlupa Plantation it was noted that the beds exposed to from two-thirds to three-fourths sunlight showed very light *Sclerotium* infection and those exposed to from one-third to one-fourth sunlight showed severe infection. Adequate facilities for draining the nursery during the rainy periods should be provided in order to avoid the spread of the fungus, which may be carried by water from one place to another.

3. *Chemical treatment.*—White(11) states that the control of root rot and crown rot of *Delphinium* caused by *S. delphinii* may be effected by removing all badly diseased plants and drenching the surrounding soil with corrosive sublimate (1: 2,000). When all the beds are heavily contaminated, susceptible hosts should not be planted for a number of years, or the soil should be changed to a depth of 8 or 10 inches. These control measures may be tried for *S. delphinii* causing seedling stem rot and seed rot of mango.

SUMMARY

1. A species of *Sclerotium,* which causes seed rot and seedling stem rot of mango, occurred in the nursery in Muntinlupa Plantation, Rizal Province, and is reported for the first time in the Philippines. Ten per cent of the mango seedlings in the nursery died of stem rot and many of the seeds rotted before or during germination, owing to the attack of the fungus.

2. The characteristic symptom of stem rot is the presence of white mycelium and sclerotial bodies of the causal fungus on the base of the stems of infected seedlings. Beneath, or a little in advance of, the growing mycelium, a blackish brown lesion develops. After the mycelium has completely encircled the stem, the leaves wilt and the seedling dies.

3. The seeds attacked by the fungus completely rot before or during germination. Numerous sclerotia develop on the cotyledons of the rotted seeds.

4. A comparative study of *Sclerotium* isolated from mango *S. rolfsii* and *S. delphinii,* in plate cultures, on various media and at different temperatures, showed that the mango *Sclerotium* resembles more closely *S. delphinii* than *S. rolfsii;* hence, the organism is referred to in this paper as a strain of *S. delphinii.*

5. The pathogenicity of the fungus has been proved on mango seedlings when inoculations were made with the mycelium and sclerotia of the fungus or when the seeds were planted in infected soil.

6. The fungus is capable of attacking various unrelated hosts, as shown by infection experiments performed in the greenhouse.

7. The fungus passes over adverse conditions by means of sclerotial bodies. The sclerotia kept in dry conditions remained alive for more than a year.

8. The disease may be controlled by strict sanitation and by proper cultural methods.

LITERATURE CITED

1. EDSON, H. A., and M. SHAPOVALOV. Parasitism of Sclerotium rolfsii on Irish potatoes. Journ. Agr. Res. 23 (1923) 41–46.
2. HIGGINS, B. B. Notes on the morphology and systematic relationships of Sclerotium rolfsii Sacc. Journ. Elisha Mitchell Sci. Soc. 37 (1922) 167–172.
3. NAKATA, K. Studies on Sclerotium rolfsii Sacc. Part I. The phenomenon of aversion and its relation to the biologic form of the fungus. Bull. Sci. Fac. Terkultura Kjusu Imp. Univ. 1 No. 4 (1925) 190.
4. NAKATA, K. Studies on Sclerotium rolfsii Sacc. Part II. The possible cause of the phenomenon of aversion in the fungus and morphological features of the phenomenon. Bull. Sci. Fac. Terkultura Kjusu Imp. Univ. 1 No. 5 (1925) 318.
5. STEVENS, F. L. A comparative study of Sclerotium rolfsii and Sclerotium delphinii. Mycologia 23 (1931) 204–222.
6. TAKAHASHI, TAKAMICHI. A Sclerotium disease of larkspur. Phytopath. 17 (1927) 239–245.
7. TAUBENHAUS, J. J. Recent studies on Sclerotium rolfsii Sacc. Journ. Agr. Res. 18 (1919) 127–138.
8. WEBER, GEORGE F. Blight of carrots caused by Sclerotium rolfsii, with geographic distribution and host range of the fungus. Phytopath. 21 (1931) 1129–1140.
9. WELCH, D. S. A sclerotial disease of cultivated Delphinium. (Abst.) Phytopath. 14 (1924) 31.
10. WESTER, P. J. The mangoes. Philip. Bur. Agr. Bull. 18 (1911) 1–60.
11. WHITE, RICHARD P. Diseases of Delphinium or larkspur. New Jersey Agr. Expt. Sta. Circ. 234 (1931) 2–4.

ILLUSTRATIONS

PLATE 1

FIG. 1. Mango seedlings showing the symptoms of wilting due to stem rot caused by *Sclerotium*. Note the mycelium and sclerotia on the base of the stems. About × 0.4.

2. Healthy seedlings. About × 0.4.

PLATE 2

FIG. 1. Seed rot of mango due to *Sclerotium*. × 1.25.

2. A mango seedling killed by *Sclerotium*, showing the mycelium and sclerotia on the cotyledons.

3. A germinating mango seed which rotted due to *Sclerotium*, showing sclerotia of the causal fungus on the rotting cotyledons.

PLATE 3

FIG. 1. A portion of a mycelial strand of the mango *Sclerotium* obtained from 6-day-old plate culture on potato-glucose agar. × 533.

2. A portion of a mycelial strand consisting of pinkish cinnamon barrel-shaped cells obtained from a 30-day-old plate culture on dextrose-beef agar. × 533.

3. Clamp connections on the main hyphæ of the mango *Sclerotium* in a 6-day-old plate culture on potato-glucose agar. × 533.

4. Short sclerotiumlike cells obtained from a 30-day-old plate culture on dextrose-beef agar. × 533.

5. Lobulate hyphæ in a 30-day-old plate culture on dextrose-beef agar. × 533.

6. A section of a large compound sclerotial body obtained from a 37-day-old plate culture on steamed oatmeal, showing smaller hyphal cells which are loosely interlaced. × 533.

7. A section of a mature sclerotial body from a 56-day-old plate culture on potato-glucose agar, showing the larger pseudoparenchyma cells beneath a boundary of a colored layer of cells. × 533. (The drawings on Plate 3 were made with the aid of a camera lucida.)

PLATE 4

FIG. 1. A portion of a plate culture of the mango *Sclerotium* on potato-glucose agar, showing maturing sclerotia with liquid exudate and also white tufts of hyphæ from which the stalk-bearing sclerotia arise. × 3.3.

2. A 35-day-old plate culture of the mango *Sclerotium* on potato-glucose agar, showing the distribution of sclerotia and pits on the larger sclerotia. About × 1.2.

PLATE 5

FIGS. 1 to 4. Sclerotia of the mango *Sclerotium*.
1. Ventral sides of sclerotia, showing hilumlike scars. × 3.3.
2. Ventral sides of sclerotia, showing concavities. × 3.3.
3. Dorsal view of sclerotia, markedly showing the pits × 3.3.
4. Composite sclerotia produced on steamed oatmeal, showing pits and spongelike appearance. × 1.5.

FIGS. 5 to 12. Sclerotia produced by eight races of *Sclerotium* on potato-glucose agar.
5. *Sclerotium delphinii* W–517.
6. *Sclerotium delphinii* I.
7. *Sclerotium delphinii* II.
8. *Sclerotium delphinii* III.
9. Mango *Sclerotium*.
10. *Sclerotium rolfsii* from pepper.
11. *Sclerotium rolfsii* from rice.
12. *Sclerotium* rolfsii from tomato.

PLATE 6

Seven-day-old plate cultures of three races of *Sclerotium* on potato-glucose agar. Slightly more than one-third natural size. Figs. 1, 5, and 9, at 35° to 35.5° C.; figs. 2, 6, and 10, at 28° to 32° C. (room temperature); figs. 3, 7, and 11, at 19° to 20° C.; and figs. 4, 8, and 12, at 6° to 8° C.

FIGS. 1 to 4. *Sclerotium rolfsii*.
5 to 8. Mango *Sclerotium*.
9 to 12. *Sclerotium delphinii* I.

PLATE 7

Twenty-day-old plate cultures on potato-glucose agar of six races of *Sclerotium* at 19° to 20° C.

FIG. 1. *Sclerotium rolfsii* on rice.
2. Mango *Sclerotium*.
3. *Sclerotium delphinii* W–517.
4. *Sclerotium delphinii* I.
5. *Sclerotium delphinii* II.
6. *Sclerotium delphinii* III.

PLATE 8

Showing antagonism between cultures of mango *Sclerotium* and *S. rolfsii* and also between cultures of *S. rolfsii* in plates of potato-glucose agar. Slightly more than five-ninths natural size.

FIG. 1. Mango *Sclerotium* (M) and *S. rolfsii* on pepper (P).
2. Mango *Sclerotium* (M) and *S. rolfsii* on rice (R).
3. Mango *Sclerotium* (M) and *S. rolfsii* on tomato (T).
4. *Sclerotium rolfsii* on pepper (P) and *S. rolfsii* on rice (R).
5. *Sclerotium rolfsii* on pepper (P) and *S. rolfsii* on tomato (T).
6. *Sclerotium rolfsii* on rice (R) and *S. rolfsii* on tomato (T).

PLATE 9

Showing antagonism of colonies of mango *Sclerotium* and *S. delphinii* strains in plates of corn-meal agar. Slightly more than five-ninths natural size.

FIG. 1. *a*, Mango *Sclerotium; b, S. delphinii* W–517.
2. *a*, Mango *Sclerotium; b, S. delphinii* I.
3. *a*, Mango *Sclerotium; b, S. delphinii* II.
4. *a*, Mango *Sclerotium; b, S. delphinii* III.

PLATE 10

FIG. 1. A healthy mango seedling (check).
2. Two diseased mango seedlings, showing wilted tops ten days after inoculation with *Sclerotium*. Nearly one-third natural size.

PLATE 11

FIG. 1. A healthy mango seedling (check). About × 0.4.
2. A wilted mango seedling dug up from one of the pots inoculated with *Sclerotium*, showing the rotted endosperms and mycelium and sclerotia of the fungus on the base of the stem. About × 0.4.

PLATE 12

A pot of diseased seedlings twelve days after inoculation with the mango *Sclerotium*, showing sclerotial production on the diseased tissues and along the mycelial strands. More than × 0.5.

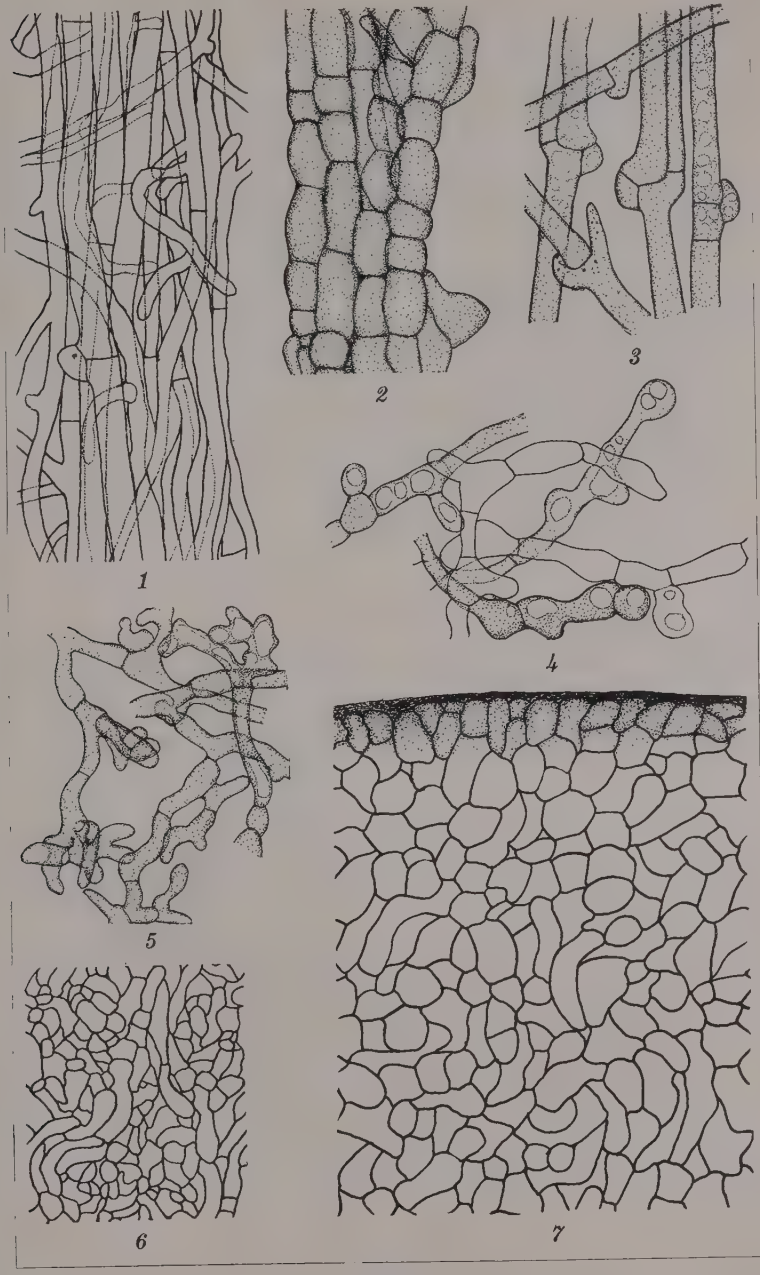
TEXT FIGURE

FIG. 1. Graphs showing sclerotial size of six strains of *Sclerotium* obtained from plate cultures on potato-glucose agar. *a, Sclerotium rolfsii* on rice; *b, Sclerotium* on mango; *c, Sclerotium delphinii* W–517; *d, Sclerotium delphinii* I; *e, Sclerotium delphinii* II; *f, Sclerotium delphinii* III.

1 2

PLATE 1.

PLATE 2.



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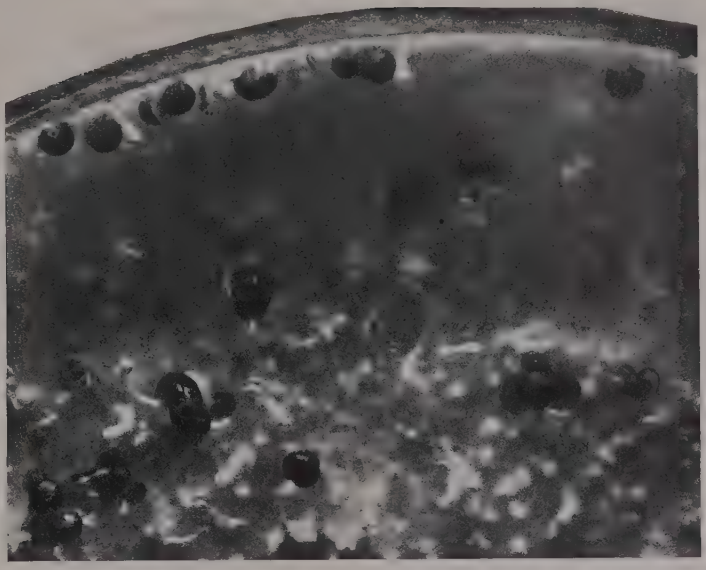

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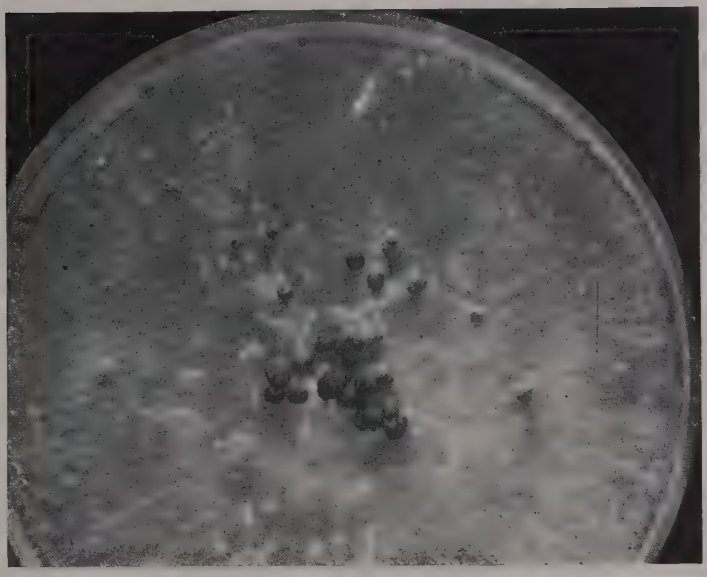

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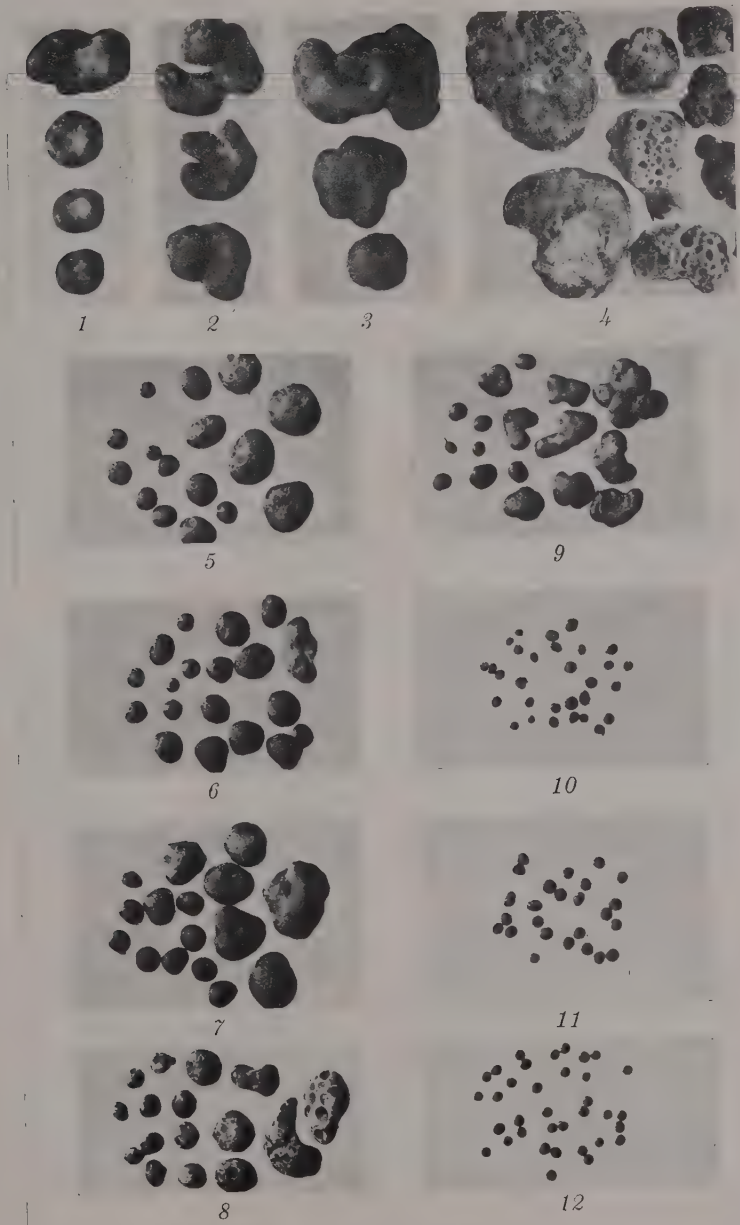

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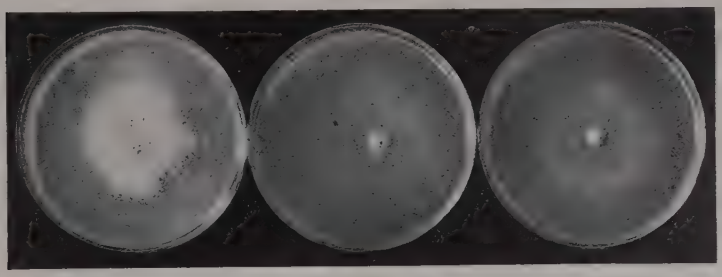

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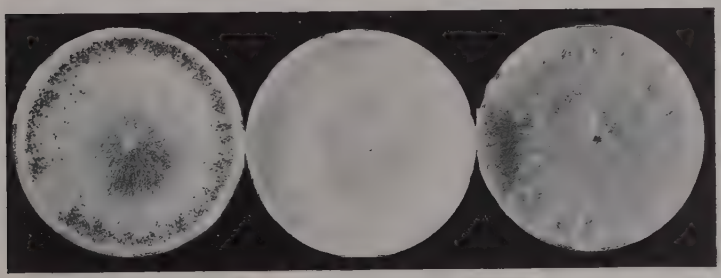

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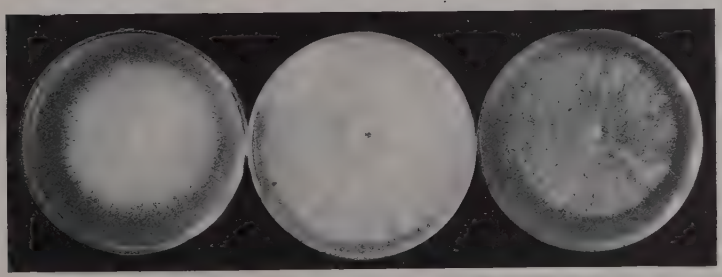

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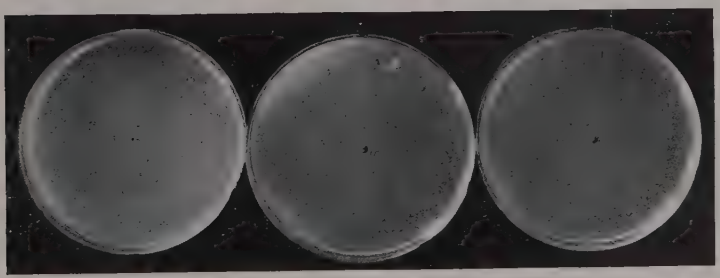
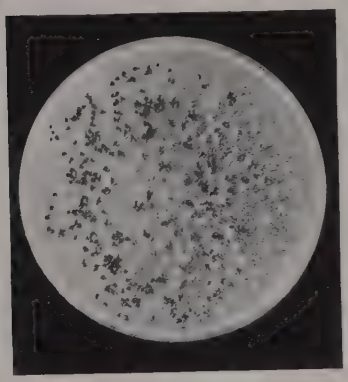


4 8 12

PLATE 6



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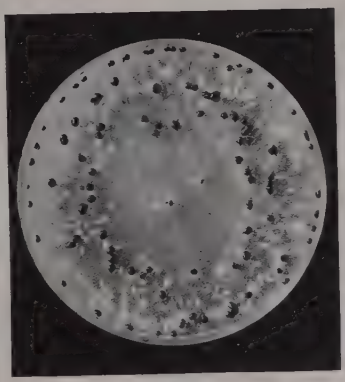

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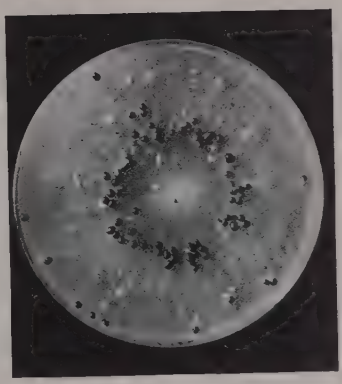

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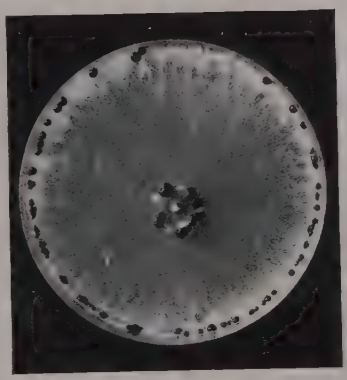

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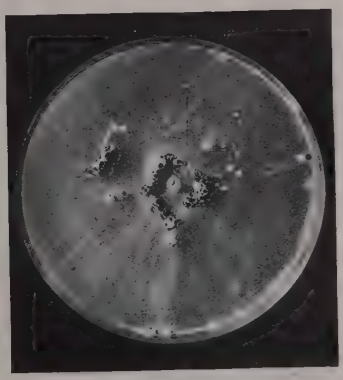

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PLATE 7.

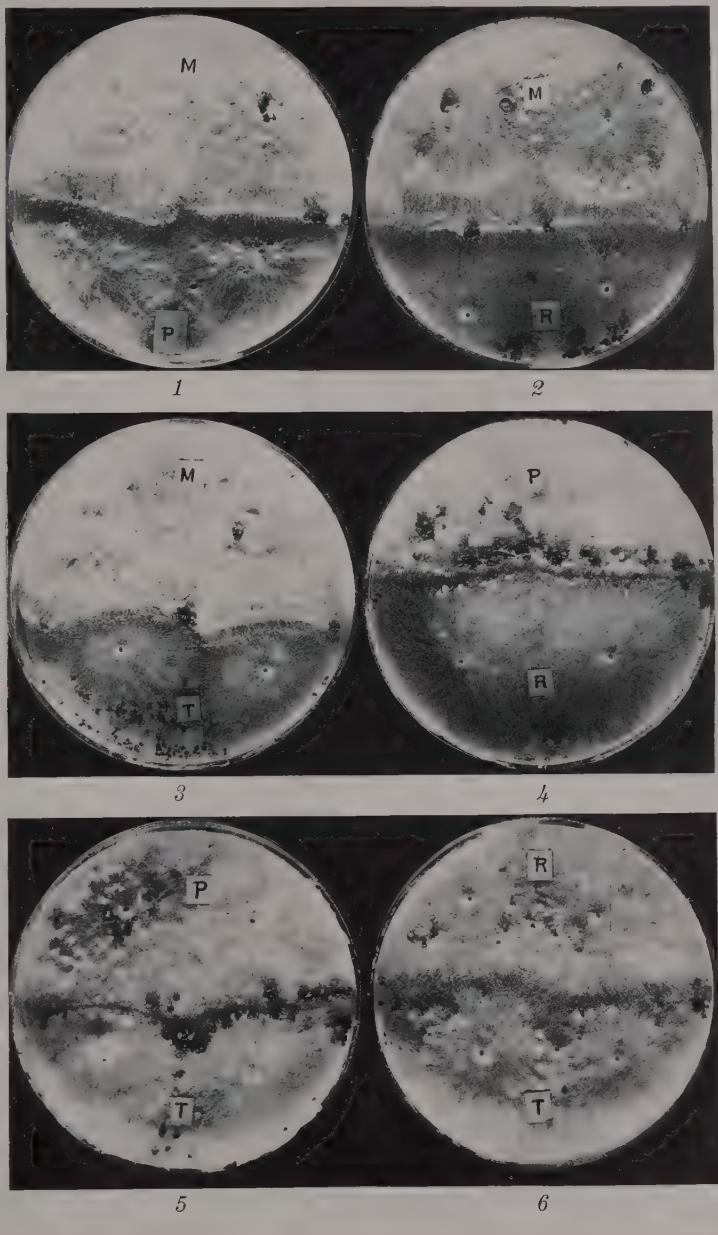


PLATE 8.

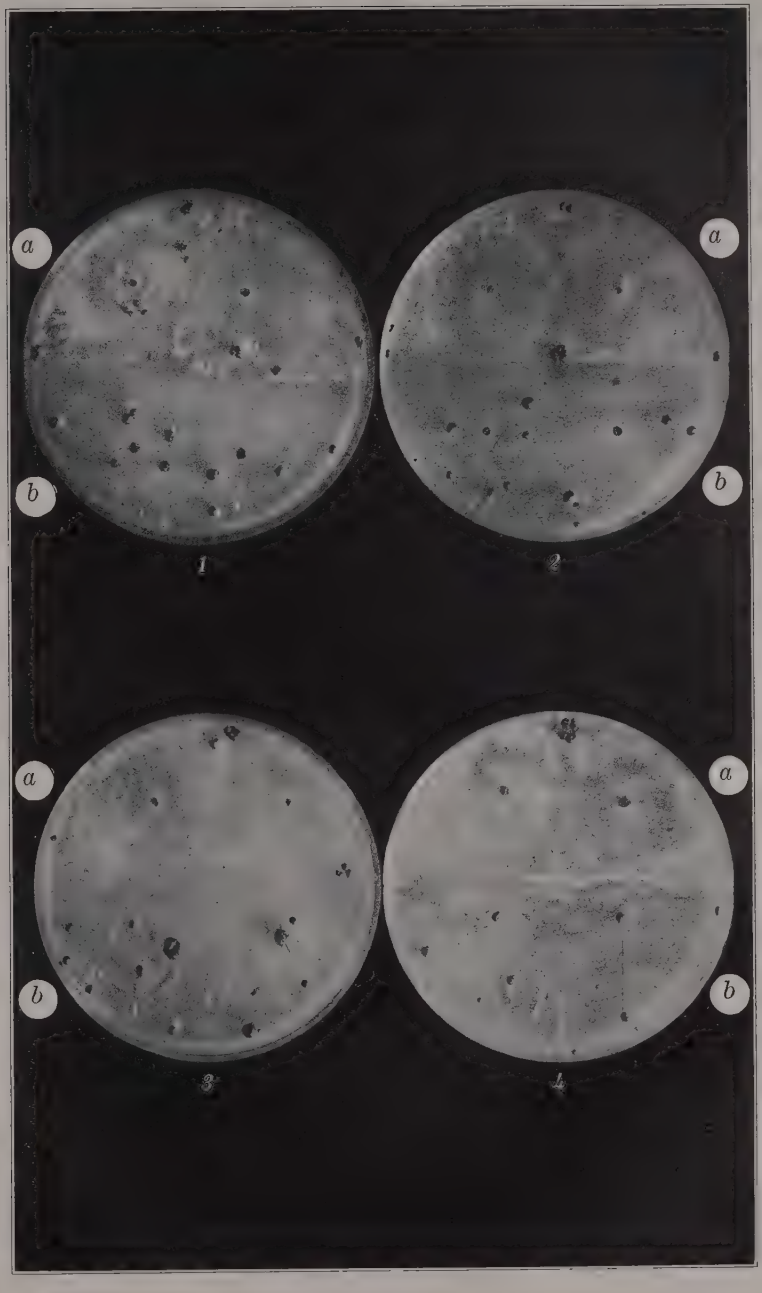
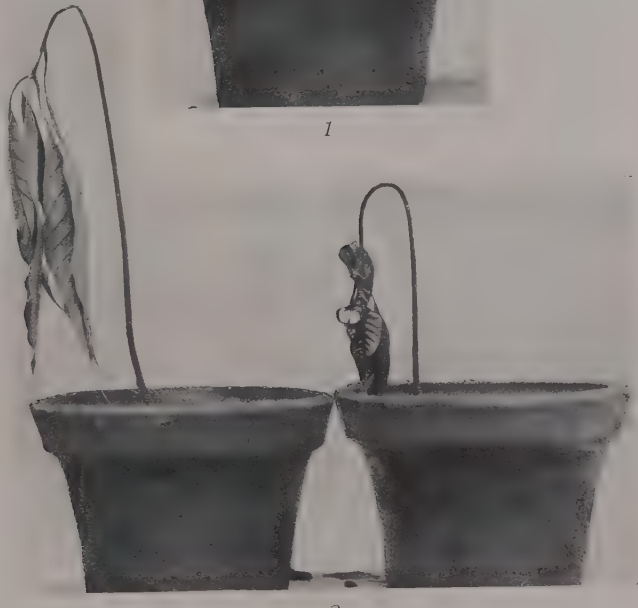


PLATE 9.

1



2

PLATE 10.

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PLATE 11.

PLATE 12.

COLOBOT ESSENTIAL OIL FROM CITRUS HYSTRIX DC. VAR. TOROSA

By SIMEONA SANTIAGO TANCHICO and AUGUSTUS P. WEST

Of the Bureau of Science, Manila

ONE PLATE

Numerous varieties of citrus fruits are grown in the Philippines, and a very good account of their cultivation is given by Wester.[1] Since the growing conditions in the Philippines are well adapted to citriculture it would seem that the cultivation of high-quality citrus fruits, merely for local consumption, could be developed into a profitable industry. Scientific citriculture on a commercial scale, in plantations, was recommended by Wester twenty years ago but, as shown by the data recorded in Table 1, considerable quantities of fruits are still imported into the Philippines.

TABLE 1.—*Citrus fruits imported into the Philippines in 1931.*[a]

Kind of fruit.	Quantity.	Value.
	Kilos.	*Pesos.*
Lemon	293,415	108,725
Orange	2,714,041	742,001
Pomelo	513,957	56,221
Total	3,521,413	906,947

[a] Annual Report of Insular Collector of Customs (1932) 145.

Various investigations have been made of the citrus fruits grown in the Philippines. The juices of these fruits contain vitamins and are used not only as a beverage but also for medicinal purposes. Gibbs and Agcaoili [2] investigated the possibilities of bottling Philippine orange and lime juices. They found that juices containing 15 per cent sugar kept well and had a

[1] Philip. Bur. Agr. Bull. 27 (1913); Philip. Agr. Rev. 8 (1915) 5.
[2] Philip. Journ. Sci. § A 7 (1912) 403.

good flavor after two years of storage. They also obtained good results with fermented orange juice.

Dovey [3] made paper from the pulp of Philippine oranges.

Wells, Agcaoili, and Orosa [4] analyzed the juices of a number of varieties of Philippine citrus fruits and also determined the yield of essential oil obtained from the peel.

Miss Orosa in her popular bulletin [5] gives directions for making jams, marmalades, preserves, and pastes from citrus fruits.

Brooks [6] examined the essential oil obtained from the rind of green Philippine oranges (naranjita) and found that the odor was just as fine as that given by imported orange-peel oil.

Recently, we purchased in one of the local markets a quantity of citrus fruits known locally as colobot. Examination of the essential oil obtained from the peel of this fruit showed that the oil had a very refined odor and appeared to be a perfumery product of good quality.

EXPERIMENTAL PROCEDURE AND RESULTS

The fruit known locally as colobot was identified by Dr. E. Quisumbing, of the Bureau of Science, as *Citrus hystrix* DC. var. *torosa* (Blanco) Wester. A description of these fruits is given by Wester.[7] The colobot is a spiny tree which attains a height of 6 or more meters. The fruits we examined had a transverse diameter ranging from 3.5 to 4 centimeters for the small fruits and 5 to 5.5 centimeters for the larger fruits. These fruits grow wild in Batangas Province and are also cultivated to some extent, as they have at present a sale value, in Manila markets, of 1 centavo each.

In some parts of the Philippines the crushed colobot fruits are mixed with gogo (pounded stems of *Entada phaseoloides*) and used as shampoo for cleaning the hair. The crushed rind of the fruit is also added to coconut oil to give it fragrance when applied to the hair.

The average proportions of the different parts of whole colobot fruits are given in Table 2.

[3] Philip. Journ. Sci. § A 7 (1912) 411.
[4] Philip. Journ. Sci. 28 (1925) 453.
[5] Philip. Bu. Sci. Pop. Bull. 1 (1926).
[6] Philip. Journ. Sci. § A 6 (1911) 346.
[7] Philip. Agr. Rev. 8 (1915) 19.

TABLE 2.—*Proportions of the different parts of whole colobot fruits.*

Part of fruit.	Per cent.
Rind	40.79
Pulp and seeds	48.80
Juice	10.41
Essential oil [a]	0.88
Essential oil [a] (in rind alone)	2.15

[a] Essential oil obtained by steam distilling.

The acidity of the juice, calculated as citric acid, was found to be 6.39 per cent.

The essential oil contained in the rind of the colobot fruits was obtained in the following manner: The peel was removed from the fruits, crushed in a grinder, and steam-distilled. The oil, which floated on top of the distillate, was then separated and dried with calcium chloride. The yield of oil was found to be 2.15 per cent, which is rather high for a natural perfumery product. The essential oil, thus obtained by distillation, had a very fragrant and refreshing (limelike) fruity odor and was found to be of better quality than the oil extracted from the rind with alcohol. This oil should serve as a useful constituent for making perfume bouquets.

The yield of essential oil obtained from the rind of these fruits varied somewhat depending upon the size and age of the fruits. Fresh firm fruits with a rind of deep green color gave the highest yield of oil, while the old withered fruits with a yellow rind gave a comparatively small yield. The large green (mature) fruits yielded considerably more essential (peel) oil than the smaller and younger fruits and the odor of the oil was also somewhat finer.

The constants of colobot oil were determined and the data are recorded in Table 3.

TABLE 3.—*Physical and chemical constants of colobot-peel oil.*

Specific gravity ($d \frac{30°}{4°}$ C.)	0.8506
Specific rotation ($A \frac{30° C.}{D}$), degrees	+ 26.59
Refractive index ($N \frac{30° C.}{D}$)	1.4665
Acid value	0.93
Saponification value	11.4

When distilled the essential oil from the peel of colobot fruit gave the results recorded in Table 4.

TABLE 4.—*Distillation of colobot-peel essential oil. (Amount of oil distilled, 100 cubic centimeters.)*

Fraction.		Amount obtained.
No.	Temperature.	
	°C.	cc.
1	Below 160	2.0
2	160–166	4.5
3	166–170	19.0
4	170–172	23.5
5	172–175	12.0
6	175–180	16.0
7 (residue)	----------	21.0

Various tests were made to determine the characteristics of colobot-peel oil.

The oil decolorized a dilute solution of potassium permanganate and also bromine water indicating the presence of double-bond compounds in the oil.

The oil gave very decided tests for aldehydes as follows:

A red color with Schiff's reagent within a time limit of two minutes.
Orange color with a glacial acetic acid solution of benzidine.
Reduced Fehling's solution, giving cuprous oxide precipitate.
Gave positive test with Tollen's reagent.

When treated with a saturated solution of sodium bisulphite a portion of the oil reacted to form crystals of a bisulphite addition product. The unaltered portion, which was separated from the crystals, had a pinenelike odor and appeared to consist of a mixture of terpenes.

The crystalline bisulphite addition product was purified by washing with alcohol and ether. It was then treated with sodium carbonate solution and distilled. The oil, which passed over into the distillate, was separated from water and dried with sodium sulphate. This oil, which had an odor resembling citronellal, was tested for this substance by shaking it with an acidified solution of mercuric sulphate. A bright yellow color which remained for some time served as a positive test for citronellal.[8]

The citronellal content of the original colobot-peel oil was determined quantitatively according to the method recommended

[8] Leach, A. E., and A. W. Winton, Food Inspection and Analysis (1920) 939.

by Baker and Smith.[9] The oil was poured into a flask, which had a narrow graduated neck, and treated with a 30 per cent solution of commercial sodium bisulphite. The citronellal combined with the sodium bisulphite. The addition of water forced the uncombined oil into the neck of the flask, where it was measured. As a result of this test the colobot-peel oil was found to contain 26 per cent citronellal.

SUMMARY

The citrus fruit colobot [*Citrus hystrix* DC. var. *torosa* (Blanco) Wester] grows wild and is also cultivated to some extent in Batangas Province, Luzon, in the Philippines. Locally the crushed fruits are mixed with gogo (pounded stems of *Entada phaseoloides*) and used as a shampoo for cleaning the hair. The crushed rind of the fruit is also added to coconut oil to give it fragrance when applied to the hair.

Recently, we investigated the essential oil obtained from the peel of the colobot fruit. The yield of essential oil obtained by steam-distilling the peel was found to be 2.15 per cent, which is rather high for a natural perfumery product. This oil has a very fragrant and refreshing (limelike) fruity odor and should serve as a useful constituent for making perfume bouquets.

The physical and chemical constants of the essential oil obtained from colobot peel were determined and also the temperatures at which the oil distils.

An investigation to determine the characteristics of this oil showed that it gave very decided tests for double-bond compounds and also for aldehydes.

When treated with sodium bisulphite solution a portion of the oil reacted to form a crystalline bisulphite addition product. The unaltered portion, which was separated from the crystals, had a pinenelike odor and appeared to consist of a mixture of terpenes. By decomposing the crystalline addition product there was obtained an oil which gave a positive test for citronellal.

The citronellal content of the original colobot-peel oil was found to be 26 per cent.

[9] The Eucalypts and their Essential Oils, Sydney Technological Museum Education Series 24 (1920) 389.

ILLUSTRATION

PLATE 1. View of whole colobot fruit and of the cross and longitudinal sections.

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PLATE 1.

THE IDENTITY OF ANOTA VIOLACEA AND RHYNCHOSTYLIS RETUSA

By EDUARDO QUISUMBING

Botanist, National Museum Division, Bureau of Science, Manila

THREE PLATES

The object of this paper is to throw some light on the nomenclatural confusion of two very interesting species of orchids which are abundant in the Philippines. True *Anota violacea* has not been very well recognized in the Philippines, and orchidologists in foreign countries have confused this species with others under different genera.

Anota violacea had been much confused with *Rhynchostylis retusa,* and often erroneously identified as *Aërides, Saccolabium, Sarcanthus,* or *Vanda.* It is often taken to be in the Philippines either as *Aërides quinquevulnerum* Lindl. or *Aërides Jarckianum* Schltr. Fortunately, however, *Aërides Jarckianum* shows marked differences in both vegetative and floral characters. Both *Anota violacea* and *Rhynchostylis retusa* are very common species in Manila, and during their season of flowering these two species are sold by peddlers in Manila; *Anota violacea* appearing in the streets and in the market during the months of December to March and *Rhynchostylis retusa* during the months of June to September. Even in culture under similar conditions the flowering period of the two species is different. Both, however, are much alike in habit and in vegetative features, particularly the leaves. When not in flower, it is very difficult to recognize them by the leaves alone unless one has had considerable experience. Deviating from the conventional method of presenting a synoptic key to these two species, I have tabulated the differences as one sees them in their living state. Also I have appended here a complete bibliography and description of the two species in question based on living specimens.

In addition to these discrepancies the two species differ in the size of the flowers, the form of the labellum, particularly the tip, the placement of the floral segments, etc., as may be seen in the accompanying colored plate.

	Anota violacea.	*Rhynchostylis retusa.*
Leaves	Thicker, wider, the yellowish lines very conspicuous.	Thinner, narrower, the yellowish lines not so conspicuous.
Racemes	Rather loosely flowered	Densely flowered.
Color of flowers	White, with conspicuous purple maculations on sepals and petals, the labellum phlox purple.	White, or with one or very few purple dots on sepals and petals, the labellum light mallow purple.
Odor of flowers	Very fragrant	Odorless.
Flowering period	December to March	June to September.
Duration of flowers	Lasting over two weeks	Lasting only about a week.
Labellum	Sessile, directly attached to the base of the footless column; disc with fleshy lines near the base and with a prominent fleshy callus beneath near the apex.	Attached to a foot, or prolongation of the base of the column; disc without fleshy thickenings (lines or calli).
Spur	Subcompressed, subacute	Compressed, broadly obtuse or truncate.
Capsules	Large, 3.8 to 4.3 cm long, 1.5 to 1.7 cm in diameter.	Small, 2 to 2.5 cm long, 0.8 to 1.1 cm in diameter.

Genus RHYNCHOSTYLIS Blume

RHYNCHOSTYLIS RETUSA (Linn.) Blume. Plate 1, figs. 1 to 4; Plate 2, fig. 1; Plate 3, fig. 1.

Rhynchostylis retusa (Linn.) Blume, Bijdr. (1825) 286, *fig. 49;* Reichb. f. in Bonpl. 5 (1857) 40, in Walp. Ann. 6 (1864) 887 (and vars.); Rolfe in Journ. Bot. 23 (1885) 216; Vidal, Phan. Cuming. Philip. (1885) 150, Rev. Pl. Vasc. Filip. (1886) 271; Hook. f., Fl. Brit. Ind. 6 (1890) 32; Veitch, Man. Orch. Pl. pt. 7 (1891) 53; *t.* (and vars.); Stein, Orchideenb. (1892) 536, *fig. 164* (and vars. and forms); Grant, Orch. Burma (1895) 290 (and vars.); Ridl. in Journ. Linn. Soc. 31 (1896) 294, 32 (1896) 356; King and Pantl in Ann. Roy. Bot. Gard. Calc. 8 (Orch. Sik.-Himal.) (1898) 213, *t. 284;* Trim., Handb. Fl. Ceylon 4 (1898) 187; Rolfe in Orch. Rev. 9 (1901) 281, *fig. 42* (var. *guttata*); Cogn. in Dict. Icon. Orch. (1902) Rhynchost. *t. 1;* J. J. Sm., Fl. Buitenz. 6 (Orch. Jav.) (1905) 629, Fig.-Atlas (1914) *fig. 471;* Duthie in Ann. Roy. Bot. Gard. Calc. 9 (Orch. Northwest Himal.) (1906) 143; Ridl., Mat. Fl. Mal. Penin. 1 (1907) 158; Ames, Orch. 2 (1908) 255, 5 (1915) 219; Merr., Sp. Blancoanae (1918) 117; Ames in Merr. in Journ. Roy. Asiat. Soc. Straits Branch, Special No. (1921) 197, in Merr. Enum. Philip. Fl. Pl. 1 (1925) 423.

Epipendrum retusum Linn., Sp. Pl. (1753) 953, ed. 2 (1763) 1351; Poir. in Lam. Encycl. Suppl. 1 (1810) 384.

Aërides retusum Sw. in Schrad. Journ. Bot. 2 (1799) 233; Willd., Sp. Pl. 4 (1805) 130; Pers., Syn. Pl. 2 (1807) 522; Spreng., Syst. Veg. 3 (1826) 719; Grah., Cat. Pl. Bomb. (1839) 204.

Limodorum retusum Sw. in Nov. Act. Ups. 6 (1799) 80.

Aërides praemorsum Willd., Sp. Pl. 4 (1805) 130; Spreng., Syst. Veg. 3 (1826) 719; Grah., Cat. Pl. Bomb. (1839) 264.

Epidendrum indicum Poir. in Lam. Encycl. Suppl. 1 (1810) 384.

Aërides undulatum SM. in Rees Cyclop. 39 (1819) No. 13.
Aërides spicatum D. DON, Prodr. Fl. Nepal. (1825) 31.
Epidendrum hippium BUCH.-HAM. ex D. DON, Prodr. Fl. Nepal. (1825) 32, in syn.
Rhynchostylis praemorsa BLUME, Bijdr. (1825) 286; HASSK. in HOEV. and DE VRIESE, Tijdschr. Nat. Gesch. 9 (1842) 143; HASSK., Pl. Jav. Rar. (1848) 128.
Sarcanthus guttatus LINDL. in Bot. Reg. 17 (1831) *t. 1443.*
Aërides guttatum ROXB. Fl. Ind. ed. 2, 3 (1832) 471; Regel in Gartenfl. 12 (1863) 339, *t. 415, figs. 8–12;* MORR. in Belg. Hort. 26 (1876) 291.
Saccolabium guttatum LINDL. in Wall. Cat. (1832) No. 7308, nomen, Gen. & Sp. Orch. (1833) 220; PAXT., Mag. Bot. 2 (1835) 141, 6 (1839) 214, 11 (1844) 211; LINDL., Sert. Orch. (1841) sub. *t. 47;* HOOK. in Bot. Mag. 70 (1844) *t. 4108;* GRIFF., Notul. 1 (1847) 22, Icon. Pl. Asiat. 1 (1847) *tt. 8, 9;* WIGHT, Icon. 5[1] (1852) 19, *t. 1745–6;* HARTING, Parad. Vindob. 2 (1848–60) *t. 13;* DE VRIESE, Ill. Orch. Ind. Neerl. (1854) *t. 14;* LINDL. in Journ. Linn. Soc. 3 (1859) 32; MIQ., Fl. Ind. Bat. 3 (1859) 693; DALZ. and GIBS., Bomb. Fl. (1861) 263; THW., Enum. Pl. Zeyl. (1864) 303; DRURY, Handb. Ind. Fl. 3 (1869) 405; PUYDT., Orch. (1880) 227, *text cut;* NAVES, Novis. App. (1882) 241; GODEFR.-LEBEUF in l'Orchidoph. 8 (1888) 273, *t.* (var. *giganteum*), 11 (1891) 11; MEYLHAND in Journ. des Orch. 2 (1892) 255, in Sem. Hort. 3 (1899) 489; WILL., Orch. Grow. Man. ed. 7 (1894) 701 and var.
Saccolabium praemorsum LINDL., Gen. & Sp. Orch. (1833) 221; PAXT., Mag. Bot. 4 (1837) 94; HASSK. in Tijdschr. Nat. Gesch. 9 (1842) 143, Pl. Jav. Rar. (1848) 128; Edit. in Fl. des Serres 7 (1851–52) 92, *text cut;* MIQ., Fl. Ind. Bat. 3 (1859) 693; DRURY, Handb. Ind. Fl. 3 (1869) 405; MEYLHAND in Journ. des Orch. 2 (1891) 255, in Sem. Hort. 3 (1899) 489, non Hook. f.
Saccolabium spicatum LINDL., Gen. & Sp. Orch. (1833) 221.
Orchis lanigera BLANCO, Fl. Filip. (1837) 641, ed. 2 (1845) 446, ed. 3, 3 (1879) 37.
Saccolabium blumei LINDL. in Bot. Reg. 27 (1841) Misc. 55; LINDL., Sert. Orch. (1841) *t. 47;* MIQ., Fl. Ind. Bat. 3 (1859) 693; PUYDT, Orch. (1880) 313, *t. 27;* NAVES, Novis. App. (1882) 241; Edit. in Gard. Chron. II 23 (1885) 572, *fig. 105;* WARNER and WILL., Orch. Alb. 4 (1885) *t. 169;* TERAN in Ill. Hort. 32 (1885) 125, *t. 566;* MEYLHAND in Journ. des Orch. 2 (1891) 254; in Sem. Hort. 3 (1899) 489, 516; WILL., Orch. Grow. Man. ed. 7 (1894) 699, *t.;* E. L. in Sem. Hort. 2 (1898) 376, *fig. 375.*
Saccolabium macrostachyum LINDL., Sert. Orch. (1841) sub. *t. 47.*
Saccolabium retusum VOIGT, Hort. Sub. Calc. (1845) 630; VAN HOUTTE in Fl. des Serres 14 (1861) *t. 1463–4;* WILL., Orch. Grow. Man. ed. 7 (1894) 703.
Saccolabium rheedii WIGHT, Icon. 5[1] (1852) 19.
Saccolabium blumei Lindl. var. *major* WILL., Orch. Grow. Man. (1852) 89, ed. 7 (1894) 699; J. LINDEN, Pescat. 1 (1860) *t. 21;* LEM. in Ill. Hort. 15 (1868) *t. 545;* MEYLHAND in Journ. des Orch. 2 (1891) 254.

Rhynchostylis guttata REICHB. F. in Bonpl. 2 (1854) 93; ROLFE in Orch. Rev. 22 (1914) 281, *fig. 33*.

Saccolabium gurwalicum LINDL. in Journ. Linn. Soc. 3 (1859) 32; REICHB. F. in Gard. Chron. II 12 (1879) 102.

Rhynchostylis gurwalica REICHB. F. in Walp. Ann. 6 (1864) 888.

Rhynchostylis retusa (Linn.) Blume var. *macrostachya* REICHB. F. in Walp. Ann. 6 (1864) 888.

Saccolabium furcatum HORT. ex Will. Orch. Grow. Man. ed. 3 (1868) 201, ed. 7 (1894) 700.

Saccolabium holfordianum HORT. ex Warner, Sel. Orch. Pl. II (1874) *t. 18*.

Saccolabium littorale REICHB. F. in Gard. Chron. II 16 (1881) 198; HOOK. F., Fl. Brit. Ind. 6 (1890) 33, cf. Ridl. in Journ. Linn. Soc. 32 (1896) 356.

? *Saccolabium berkeleyi* REICHB. F. in Gard. Chron. II 19 (1883) 814, Edit. in l'Orchidoph. 3 (1883) 693; HOOK. F., Fl. Brit. Ind. 6 (1890) 33; WILL., Orch. Grow. Man. ed. 7 (1894) 699.

Saccolabium heathii HORT. ex Gard. Chron. II 24 (1885) 369.

Saccolabium turneri WILL., Orch. Grow. Man. ed. 6 (1885) 568, ed. 7 (1894) 703.

Saccolabium blumei Lindl. var. *russellianum* WILL. in Warner and Will., Orch. Alb. 5 (1886) *t. 238*; WILL., Orch. Grow. Man. ed. 6 (1885) 564, ed. 7 (1894) 699.

Gastrochilus blumei KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus gorwalicus KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus retusus KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus rheedii KTZE., Rev. Gen. Pl. 2 (1891) 661.

Gastrochilus spicatus KTZE., Rev. Gen. Pl. 2 (1891) 661.

? *Rhynchostylis violacea* (Lindl.) Reichb. f. var. *berkeleyi* STEIN, Orchideenb. (1882) 537.

Gastrochilus praemorsus DUR. and JACKS., Ind. Kew. Suppl. 1 (1903) 178, non Ktze.

Rhynchostylis violacea AMES, Orch. 1 (1905) 105, non Reichb. f.

Rhynchostylis retusa

R: foliis apice bifarium retusis.

Synon: *Aerides retusa*.-Sw.

Crescit: supra arbores in Provinciis Bantam et Buitenzorg.

Floret: Februario etc. Blume, Bijdr. 286.

Epiphytic on tree trunks, particularly on *Bauhinia malabarica, Gliricidia sepium,* and *Lagerstroemia speciosa.* Stems stout, 16 to 32 cm long. Roots stout, greenish gray with few white spots, 8 to 12 mm in diameter. Leaves distichous, spreading or arching, lorate, deeply channeled, firm, thickly coriaceous, 11 to 39 cm long, 1.2 to 3.5 cm wide when flattened, imbricated at the base, obliquely 2-lobed or retuse at the apex, dark green above, paler beneath with conspicuous longitudinal yellowish lines. Racemes cylindrical, long, densely-flowered, pendulous, 1 to 4 in a plant, usually 27 to 33.5 cm long, 4 to 5.5 cm in dia-

meter; the peduncles 7 to 10.5 cm long. Flowers crowded, odorless, numerous, 1.7 to 2.3 cm across; pedicellate ovary grooved, 1.5 to 1.8 cm long, or about 1 cm long at the tips of the racemes; bracts membranaceous, 5 to 6 mm long. Sepals and petals spreading, white, sometimes with very few minute light mallow purple dots. Lateral sepals broadly and obliquely ovate, obtuse, 9 to 10 mm long, 7 to 8 mm wide, 7-nerved. Dorsal sepal smaller than the lateral sepals, broadly elliptic, rounded or broadly obtuse, 8 to 9.5 mm long, 6 to 6.5 mm wide, 7-nerved. Petals smaller and narrower than the sepals, oblong-ovate, rounded, 9 to 10 mm long, 4.5 to 5 mm wide, 5-nerved. Labellum strongly saccate-spurred at the base, attached to a foot, or prolongation of the column about 3 mm long, light mallow purple, white at the tip; spur much compressed, white, cylindric-oblong, broadly obtuse to subtruncate, 6.5 to 8 mm long, lamina reflexed at the apex, oblong-spatulate, rounded and apiculate or slightly retuse at the tip, 11 to 12 mm long, 7 to 8 mm wide at the widest portion near the very tip. Column very short, glass-green, about 3 mm long; anther ovoid, beaked; pollinia 2, subglobose or globose, yellowish. Capsules ellipsoid, 1.6 to 2.5 cm long, 7 to 11 mm in diameter, 6-ribbed, the alternate wings 1 to 2 mm wide.

This widely distributed species, which spreads over a geographical area larger perhaps than that of most Indo-Malaysian species, is restricted in the Philippines to Luzon Island, particularly in Bataan and Rizal Provinces, and is represented in the Bureau of Science herbarium by the following collections: *Cuming 2072, Lyon 13, Whitford 36, Merrill 4190, Merrill, Sp. Blancoanae 1030, Reillo 9, Weber 10, Bur. Sci. 13548 Ramos, 85610 Quisumbing.*

Occurs in India, Ceylon, Burma, Malay Peninsula, Siam, Java, and Borneo.

Genus ANOTA Schlechter

ANOTA VIOLACEA (Lindl.) Schltr. Plate 1, figs. 5 to 8; Plate 2, fig. 2; Plate 3, fig. 2.

Anota violacea (Lindl.) SCHLTR., Orchideen (1914) 588.

Vanda violacea LINDL. in Bot. Reg. 27 (1841) Misc. 12, 33 (1847) *t. 30;* PAXT., Mag. Bot. 9 (1842) 119; VAN HOUTTE in Fl. des Serres 17 (1868–69) 92; AMES in Merr. Enum. Philip. Fl. Pl. 1 (1925) 438.

Rhynchostylis violacea REICHB. F. in Bonpl. 2 (1854) 93, in Walp. Ann. 6 (1864) 888; VAN HOUTTE in Fl. des Serres 17 (1868–69) 91; STEIN, Orchideenb. (1892) 537; AMES, Orch. 5 (1915) 219.

Saccolabium violaceum REICHB. F. in Bonpl. 2 (1854) 93, in syn.; WARNER, Sel. Orch. I (1862–65) *t. 14;* PUYDT, Orch. (1880) 317,

t. 39; NAVES, Novis. App. (1882) 241; VEITCH, Man. Orch. Pl. pt. 7 (1891) 117; CERON, Cat. Pl. Herb. Manila (1892) 168.

The original description reads as follows:

"VANDA *violăcĕă;* foliis canaliculatis obliquè abscissis rotundatis, racemis multiflores densis pedunculatis, sepalis obovato-oblongis obtusis planis incurvis petalis multò angustioribus, labello oblongo apiculato plano: venis 5 crassis elevatis, sacco intus pubescente.

A very pretty epiphyte, sent from Manilla to Messrs. Loddiges by Mr. Cuming. The flowers are in short racemes, rather large, with an ivory white ground spotted with light violet; of the latter colour there is one large blotch within the extremity of each sepal and petal, and a few small dots are scattered over their surface; the lip is wholly violet. The flowers have a faint and rather disagreeable smell." Lindl. Bot. Reg. 27 (1841) Misc. 12.

Epiphytic on similar hosts as *Rhynchostylis retusa.* Stems stout, usually short, 10 to 18 cm long, (rarely up to 40 cm long), 0.8 to 1.7 cm in diameter. Leaves distichous, broadly strap-shaped, decurved, deeply channeled, firm, very thickly coriaceous, 14 (rarely 6) to 31 cm long, 2 to 4.2 cm wide when flattened, imbricated at the base, unequally 2-lobed or retuse at the apex, green with very conspicuous yellowish lines. Racemes pendulous, shorter than the leaves, loosely-flowered, 7 to 25 cm long, 4.5 to 6.5 cm in diameter, 3 to 5 on a plant. Flowers fragrant or with a distinct odor, 2.5 to 3 cm across; pedicellate ovary, 1.6 to 2.3 cm long; pedicel white; ovary oural green. Sepals and petals fleshy, white, conspicuously spotted with light amparo purple. Sepals oblong-ovate or elliptic-ovate, obtuse, or subacute, 13.5 to 15 mm long, 8 to 9 mm wide, 7- to 8-nerved. Petals smaller than the sepals, oblanceolate or subspatulate, obtuse, 11.5 to 13 mm long, 5 to 6 mm wide, 5-nerved. Labellum fleshy, attached directly to the very abbreviated column-foot which is without prolongation, subquadrate-pandurate, 12 to 13 mm long, 8.5 to 9 mm wide at the widest portion, phlox purple, undulate, sharply retuse-apiculate or with a small ovate-lanceolate lobule at the apex; disc with 5 approximate fleshy ridges at the base and a nipplelike callus beneath near the apex; spur flattened, conic-ellipsoid, 6 to 7 mm long, 3.5 to 4 mm wide, phlox pink flushed with yellowish citrine. Column very short, stout, subterete, 2.5 to 3 mm long, Biscay green minutely spotted with pansy purple. Anther ovoid, hazel, with white beak, about 2.5 mm long. Capsules large, ellipsoid-obconic, 3.5 to 4.3 cm long, 1.5 to 1.7 cm in diameter, sharply 3-angled in section with the thick keels at the angles, 3.5 to 5 mm wide, and with a broad flat band in the center between the sharp corners.

An endemic species known to science only by collections from Nueva Ecija and Rizal Provinces, Luzon Island, and represented by the following numbers: *Lyon 50, Native collector s. n., Bur. Sci. 3090 Curran, 21334 Ramos.*

A species with vegetative characters similar to those of *Rhynchostylis retusa* (L.) Blume but differing radically in the structure of the flowers and in the other characters indicated above.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Rhynchostylis retusa* (L.) Blume; front view of a flower, × 1.
2. *Rhynchostylis retusa* (L.) Blume; side view of a flower, × 1.
3. *Rhynchostylis retusa* (L.) Blume; labellum viewed from above, × 2.
4. *Rhynchostylis retusa* (L.) Blume; side view of pedicellate ovary, column, and labellum, × 2.
5. *Anota violacea* (Lindl.) Schltr.; front view of a flower, × 1.
6. *Anota violacea* (Lindl.) Schltr.; side view of a flower, × 1.
7. *Anota violacea* (Lindl.) Schltr.; labellum viewed from above, × 2.
8. *Anota violacea* (Lindl.) Schltr.; side view of pedicellate ovary, column, and labellum, × 2.

PLATE 2

FIG. 1. *Rhynchostylis retusa* (L.) Blume; habit, much reduced.
2. *Anota violacea* (Lindl.) Schltr.; habit, much reduced.

PLATE 3

FIG. 1. *Rhynchostylis retusa* (L.) Blume; portion of the raceme showing slightly enlarged flowers.
2. *Anota violacea* (Lindl.) Schltr.; racemes of flowers, slightly reduced.

PLATE 1.

1

2

PLATE 2.

1

2

PLATE 3.

STABILITY OF A NEW CHLORINE PRODUCT

By R. H. Aguilar and Lourdes Ocampo

Of the Bureau of Science, Manila

ONE TEXT FIGURE

Chlorine is, no doubt, one of the most useful chemical products known to science. In the industries, especially in the textile industry, it is used as a bleaching agent; in water supplies, in hospitals, and in medical clinics, as well as in homes, it is used as a disinfectant. Great quantities of chlorine gas were used during the World War. For these reasons the manufacture of chlorine on a commercial basis has become one of the most important problems of industrial chemistry.

Since the discovery of this element by Scheele in 1774, various methods have been developed to prepare it in a form which would make it safe and easy to handle during transportation and distribution. The first attempt in this direction was made by Tennant [1] in Great Britain in 1798. The method consisted in saturating lime with gaseous chlorine:

$$2\ Ca(OH)_2 + 2\ Cl_2 \leftrightarrows 2\ H_2O + Ca(OCl)_2 + CaCl_2.$$

The highest quantity of available chlorine obtainable by this method, however, is 36 per cent, and the product is commercially known as "bleaching powder."

Bleaching powder is made on a large scale in electrolytic alkali works, in order to utilize the large quantities of chlorine that result as a by-product. It is perhaps for this reason that bleaching powder is the cheapest chlorine-carrier produced at present. It is, however, rather unstable in its composition, and under normal conditions prevailing in the Philippines, it deteriorates on storage at a fairly rapid and irregular rate.[2]

In order to eliminate, as far as possible, these objectionable qualities of calcium hypochlorite in bleaching powder, and to manufacture a more stable and a more highly concentrated product, various methods have been devised and developed. Of these

[1] Molinari, E., General and Industrial Chemistry. P. Blakiston's Son & Co., Philadelphia (1920) 622.

[2] Aguilar, R. H., Philip. Journ. Sci. 47 (1932) 235.

methods, the one followed by the Elektron Works at Griesheim,[3] which dates from 1907, may be mentioned. This method consists in saturating milk of lime almost completely with chlorine, and continually stirring it. After filtration the liquid is slowly evaporated in vacuo, thus obtaining solid chloride of lime, purer, more stable, and almost entirely soluble in water.

Very recently a similar chlorine product, commercially known as HTH, appeared on the Philippine market. This product is manufactured by the Mathieson Alkali Works by their own process, and its properties are described by Gage[4] as (*a*) an unusually stable hypochlorite compound; (*b*) of practically uniform composition; (*c*) possessing a high content of available chlorine; (*d*) readily soluble in water; and (*e*) not caking or deliquescing.

COMPOSITION OF THE SAMPLE

The sample tested was furnished by a local drug store, and upon examination gave the following results:

	Per cent.
Sample, 5 g in 200 cc of distilled water.	
Insoluble in water	2.0
Soluble in water	98.0
Total	100.0
Available chlorine	61.0

After a lapse of two years, the bottled sample in the laboratory was again examined, and the following results were obtained.

	Per cent.
Insoluble in water	3.5
Soluble in water	96.5
Total	100.0
Available chlorine	35.0

The principal constituents of the soluble portion besides calcium hypochlorite are KCl, NaCl, and $CaCl_2$. The insoluble portion is mainly $CaCO_3$. SiO_2 and R_2O_3 are both present in the soluble and insoluble portions.

The increase of insoluble matter after two years storage may be attributed to CO_2 in the air, which gained access into the container every time it was opened for the collection of a sample

[3] Molinari, op. cit. 624.

[4] Chem. and Metal. Eng. 36 (1929) 295.

for test. The CO_2 in contact with lime forms the insoluble calcium carbonate.

GENERAL PROCEDURE

The sample of HTH, which was received in original three-liter tin container, was opened, thoroughly mixed, and analyzed. Then a portion of it was placed into two glass bottles, the remaining portion was distributed in several 7 c.c. amber-colored vials, all of which were tightly stoppered. One of the bottles and several vials were stored in the refrigerator, wherein the temperature was maintained at approximately 10°C.; the other bottle and the rest of the vials were stored in the laboratory at an average room temperature of 29° C. The monthly determinations of available chlorine were made according to standard methods. The contents of the bottle were thoroughly mixed by shaking before the sample for analysis was collected. In the case of samples stored in vials, two vials were taken for every test. In some instances marked discrepancies were noticed in the results of tests for available chlorine. When this happened, a third, or even a fourth vial, was tested to check the first determinations.

RESULTS OF TESTS

The results of tests are shown in fig. 1. The curves embrace an observation period of two years. It appears evident from the direction of the curves, that the temperature bears a marked influence on the stability of the bleaching compound. The size of the container and the material of which it is made [5] affect, to a certain extent, its keeping qualities.

There is no noticeable difference between the rates of deterioration of the samples stored in vials and the sample stored in a large bottle at the temperature prevailing in the refrigerator. At the average laboratory temperature, however, the difference is very apparent.

In the course of these observations, it has been noted that the samples in some vials deteriorated more rapidly than in others, and in many instances, redeterminations for available chlorine had to be made to obtain concordant and consistent results. This behavior, which is graphically shown in fig. 1, indicates that the bleaching compound stored in small containers, like

[5] Philip. Journ. Sci. 47 (1932) 236.

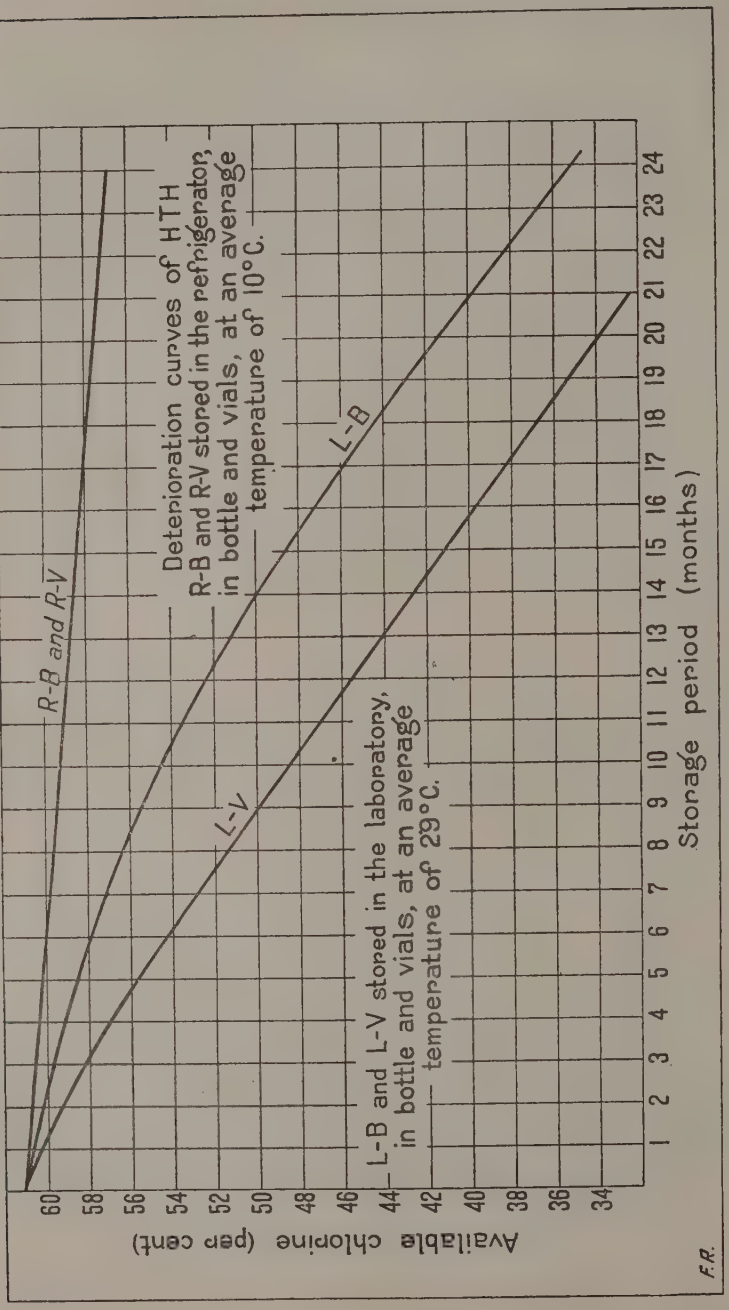

FIG. 1. Deterioration curves of HTH.

these vials, is subject to a relatively more rapid rate of deterioration than the same compound stored in large containers.

FORM AND DIRECTION OF THE CURVES

The deterioration curves plotted on a reduced scale are practically straight lines; but the same curves plotted on an enlarged scale, as shown in fig. 1, are slightly curved downward. The curved direction is especially more noticeable in curve L–B., representing the deterioration rate of the sample kept in a large bottle.

The relatively more rapid deterioration of the samples kept in small containers such as the glass vials used in these tests is shown in curve L–V. At the end of twenty months the samples stored in vials had lost 41 per cent available chlorine, while the same sample stored in a large bottle, lost 32 per cent for the same length of time.

Comparing these curves with those obtained by Gage in 1929 [6] the following relative deterioration values, at different temperatures and after a storage period of about eight months five days, may be obtained.

Loss of available chlorine.

Temperature °C.	Loss. Per cent.
10	2.46
22.5 (Gage's)	4.76
29	7.80
45 (Gage's)	32.69

Although these results show no strict proportional relation between the increase of temperature and the percentage losses of available chlorine, they are yet significant in that they furnish an indication of the uniform quality of the manufactured product. The percentage losses of available chlorine of two different samples appear remarkably consistent with the increase of temperature.

CONCLUSION

HTH is a high-test chlorine-carrier, soluble in water, and exceedingly more stable than bleaching powder of good quality under the normal storage conditions prevailing in the Philippines.

[6] Chem. and Metal. Eng. 36 (1929) 295.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Deterioration curves of HTH.

RECTIFICATIONS

Par E. FLEUTIAUX
Nogent-sur-Marne, France

FORNAX CORRECTUS nov. nom. pour:

Fornax haddeni FLEUTIAUX, Philip. Journ. Sci. 49 (December, 1932) 565 (non *Fornax* (*Ceratus*) *haddeni* FLEUTIAUX, Proc. Haw. Ent. Soc. (November, 1932) 45.

ELATER CONSPURCATUS Candèze, 1889.

Megapenthes cinctus FLEUTIAUX, Philip. Journ. Sci. 49 (1932) 567.

ADDITIONS TO THE APHID FAUNA OF FORMOSA (HEMIPTERA), II[1]

By Ryoichi Takahashi

Of the Department of Agriculture, Government Research Institute, Formosa

THREE TEXT FIGURES

LACHNUS FICI sp. nov.

Wingless viviparous female.—Brownish black, with the third antennal joint and tibiæ, excepting the distal parts, blackish brown in specimens preserved in alcohol. In specimens treated with caustic potash, antennæ and legs mostly yellowish brown, dorsum dusky on the last abdominal segment, with numerous small pale brown irregular areas densely scattered, and some small dark brown patches, the lateral ones of which are transversely linear. Body oval, covered with many rather fine setæ, which are a little curved and shorter than the first antennal joint. Head distinctly divided, with hairs nearly as long as those on the antennæ and abdomen. Eyes normal. Antennæ slender, with many setæ, which are a little or not curved, equal in length and nearly as long as those on the head; the third joint with one small circular sensorium or none near the tip; the fourth with one or two similar sensoria near the tip; the fifth with the usual sensorium large; the relative length of joints about as follows: III—42, IV—15, V—15, VI—10 + 4. Rostrum reaching beyond the hind coxæ. Abdomen not reticulated on the dorsum, on the dorsum with a small, but distinct, obtuse median tubercle, which is pale dusky in specimens treated with potash, rounded at the tip, much smaller than the cornicle, and with about five small transparent irregular areas on the surface. Cornicles on large cones much wider than long and covered with hairs. Cauda short, broadly rounded, hairy. Anal plate broadly rounded. Legs long, covered with setæ; tibiæ much stouter than the antennæ; hind tarsi not striate, much longer than the fourth antennal joint, the distal joint nearly thrice as long as the basal.

[1] Part I was published in the Philippine Journal of Science 48 (1932) 69–73.

Length of body, about 4.5 millimeters; antenna, about 1.75; hind tibia, about 3.0; hair on body, about 0.065; diameter of cornicle at apex, about 0.171.

Winged viviparous female.—Brownish black, black on the antennæ, mesothorax, distal halves of tibiæ, and on the tarsi. Fore wings distinctly blackish brown on the basal part, very narrowly dusky on the hind margin, very slightly clouded along the basal parts of the first and second obliques, and narrowly so along the front margin beyond the stigma, the basal blackish brown part not reaching the first oblique; hind wings also distinctly blackish brown on the basal part; stigma and veins blackish brown. (The above color notes are from specimens preserved in alcohol.) In specimens treated with caustic potash, dorsum with some very small dark brown patches, and a pair of large dusky bands on the last segment. Body with rather fine setæ. Head with many curved setæ a little shorter than the first antennal joint. Antennæ a little corrugated on the surface except on the basal two joints, with many setæ, which are slightly curved and as long as those on the head; the third joint with about twenty-six to thirty-eight small or large, circular or subcircular sensoria scattered over the whole length, which are sometimes much fewer (about nine) and absent on the basal part; the fourth with about five to seven similar sensoria not in a row over the whole length; the fifth with one to five small circular sensoria nearly in a row besides a large primary one; the sixth without secondary sensoria; the relative lengths of joints about as follows: III—45, IV—16, V—16, VI—10 + 4. Rostrum reaching beyond the hind coxæ. Abdomen indistinctly minutely reticulated on the dorsum, with hairs nearly as long as those on the head. Wings long; fore wings imbricated on the distal half; stigma much elongated, not reaching the distal end of stigmatic vein; the first oblique nearly straight; the second slightly curved; the third distinct, but slenderer than the second, obsolete on the base, twice branched, the upper branch reaching the tip of wing; stigmatic vein nearly as stout as the third oblique, very slightly curved; hind wings imbricated, with two divergent obliques; hooklets 5. Legs long and slender, covered with setæ, which are slightly curved and stouter than those on the abdomen; hind tarsi longer than the fourth antennal joint, the distal joint nearly thrice as long as the basal.

Length of body, about 5 millimeters; antenna, about 1.6; fore wing, about 6.2; hind tibia, about 3.4; hair on body, about 0.078; diameter of cornicle at apex, about 0.18.

Host.—*Ficus* sp., attacking the branch.

Habitat.—Eboshiyama, near Doba, Rato-Gun.

Many specimens were collected by Dr. T. Shiraki and Mr. M. Chujo, May 20,1933. This species differs from other species of the genus *Lachnus* (*Pterochlorus* Baker) in the basal part of the wings being distinctly blackish brown.

ANOECIA CORNI Fabricius.

Wingless viviparous female.—Dark yellowish brown, blackish on the dorsum. Antennæ and legs brownish black. (Color notes are from specimens preserved in alcohol.) Body oval, covered with rather long fine hairs slightly curved and subequal in length. Head not divided, with many hairs shorter than the first antennal joint. Eyes rather small, of many facets, with normal ocular tubercles. Frontal tubercles absent. Antennæ much shorter than the body, rather stout, six-jointed, covered with long fine hairs, most of which are nearly as long as the first antennal joint; the first joint slightly shorter, but a little stouter, than the second; the third straight, not imbricated, constricted at the base, with one small circular sensorium or none at the tip; the fourth slightly narrowed towards the base, with one or two similar sensoria on the distal half; the fifth similar in shape to the fourth, with the usual circular sensorium large; the sixth striate on the distal part, not pointed apically, very slightly constricted at the base of the distal part; the relative length of joints about as follows: III—83, IV—31, V—35, VI—39 + 10. Rostrum long, stout, reaching a little beyond the hind coxæ, not pointed at the tip, hairy. Cornicles very short, represented nearly as mere rings, but much larger in diameter than the primary sensorium, not on cones. Cauda very short, broadly rounded, hairy. Legs long, covered with long fine hairs; tibiæ stouter than the third antennal joint; hind tarsi long, not striate, longer than the fifth antennal joint, the basal joint short, with some long bristles.

Length of body, about 2.8 millimeters; antenna, about 1.07; hind tibia, about 1.10; longer hair on antenna, about 0.074; width of third antennal joint, about 0.055; diameter of cornicle, about 0.055.

Host.—*Saccharum officinarum,* attacking the subterranean part.

Habitat.—Seiton, Taichu Prefecture.

Some specimens were taken by Mr. M. Yanagihara March 20, 1933. The dorsum becomes dusky when treated with caustic

potash. This species spends the summer on the roots of the Gramineæ and the winter on *Cornus* in temperate countries, but in Formosa it has not been found on *Cornus*.

GREENIDEA DECASPERMI sp. nov.

Wingless viviparous female.—Yellowish brown, blackish on the dorsum of abdomen except on the margin. Antennæ black on the distal half. Cornicles black, a little paler on the distal part. Legs yellowish brown. Cauda pale yellowish brown. Hairs on the body brownish black. Body chitinized, with numerous granules on the ventral sides of thorax and abdomen, on the dorsum with many very long stout bristles which are slightly curved and a little branched apically, but those on the posterior part of abdomen scarcely or not branched. Head fused with the pronotum, nearly straight on the front, with about ten dorsal bristles longer than the first antennal joint. Frontal tubercles absent. Eyes normal. Antennæ long, slender, striate, with some very long simple bristles; third joint wanting sensoria; the relative lengths of joints about as follows: III—25, IV—14, V—14, VI—13 + 29. Rostrum slender, reaching a little beyond the hind coxæ. Abdomen circular when seen from above, with a little longer bristles. Cornicles long, stout, slightly curved, narrowed at the base, tapering on the distal portion, broadest near the base, narrowest on the distal part, about six times as long as wide, a little longer than the sixth antennal joint, transversely reticulated distinctly on the basal small area, with many very long stout bristles, and numerous spinules over the distal part. Caudal segment with a process, which is apparently longer than wide, rounded apically, tapering and a little expanded basally. Legs slender, with some bristles; tibiæ striate, hind tibiæ as stout as the third antennal joint; femora striate, with two long, more-eminent bristles on the distal part, which are sometimes a little branched at the tip; hind tarsi much shorter than the bristles on the abdomen.

Length of body, about 1.75 millimeters; antenna, about 1.8; cornicle, about 0.77; caudal process, about 0.041; hind tibia, about 0.75; hair on abdomen, about 0.138; hair on cornicle, about 0.208.

Winged viviparous female.—Antennæ black. Cornicles black, a little paler on the distal part. Wing veins blackish brown, stigma dusky. Bristles on the head and thorax much longer than those on the abdomen and a few of them sometimes a little branched. The third antennal joint a little curved, with about seventeen to twenty, circular or oval, small and rather large

sensoria irregularly arranged nearly in a row along the whole length except on the distal small part; the relative lengths of joints about as follows: III—40, IV—23, V—23, VI—17 + ?. Cornicles very long, slender, cylindrical, slightly curved, slightly narrowed on the distal part, striate or indistinctly reticulated transversely except on the distal part, nearly as stout as the femur, with many very long bristles, and numerous spinules on the distal part. Femora striate; tibiæ striate, slender, hind tibiæ somewhat curved, slenderer than the third antennal joint. Wing veins normal.

Length of body, about 2 millimeters; cornicle, about 1.65; fore wing, about 2.7; hind tibia, about 1.5; longer bristle on head, about 0.138; longer dorsal bristle on abdomen, about 0.06; longer bristle on cornicle, about 0.28.

Host.—Decaspermum fruticosum.

Habitat.—Taihoku, Suisha.

A few specimens were collected by the author April 24, 1933, at Taihoku, and in June, 1933, at Suisha. This species seems to be allied to *Greenidea mangiferæ* Takahashi, but may be distinguished from it by the longer caudal process and the characters of cornicles of the wingless form, and by the larger sensoria on the third antennal joint of the winged form.

ACYRTHOSIPHON KUWANAI sp. nov.

Wingless viviparous female.—Shining brownish yellow. In specimens treated with caustic potash, dorsum somewhat pale brownish, antennæ yellowish brown, blackish on the apices of the third, fourth, and fifth joints and on the sixth, black on the first except on the base paler, cornicles dusky yellowish brown, with the distal parts darker, legs yellowish brown, black on the distal halves of femora, the distal parts of tibiæ and on the tarsi, cauda yellowish brown. Body oval. Head with numerous spinules over the dorsum except on the median part and near the eyes, eight rather long stout stiff dorsal setæ very slightly or scarcely knobbed at the tip, and a pair of curved stout setæ on the front. Frontal tubercles large, distinctly convex and with two stout setæ on the mesal side, slightly diverging or nearly parallel on the mesal sides. Antennæ very long, slender, imbricated; the first joint very large, twice as long as the second, a little convex on the middle of mesal side; the third and the following joints with a few very small stout setæ, some of which are very slightly capitate; the third with one or two small circular sensoria on the basal part; the fourth lacking sensoria; the rel-

ative lengths of joints about as follows: III—49, IV—36, V—35, VI—11 + 48. Rostrum stout, rounded apically, reaching the hind coxæ. Thorax with many rows of spinules on the venter and more or less reticulated on the middle of metasternum; pronotum with a few slightly capitate setæ a little shorter than those on the dorsum of head; mesonota and metanota and dorsum of the abdomen with a few minute setæ a little expanded on the middle and pointed apically; abdomen distinctly corrugated behind each cornicle, with a few curved stout setæ slightly capitate on the dorsum of the posterior part, which are a little shorter than the setæ on the head, and with some simple ventral

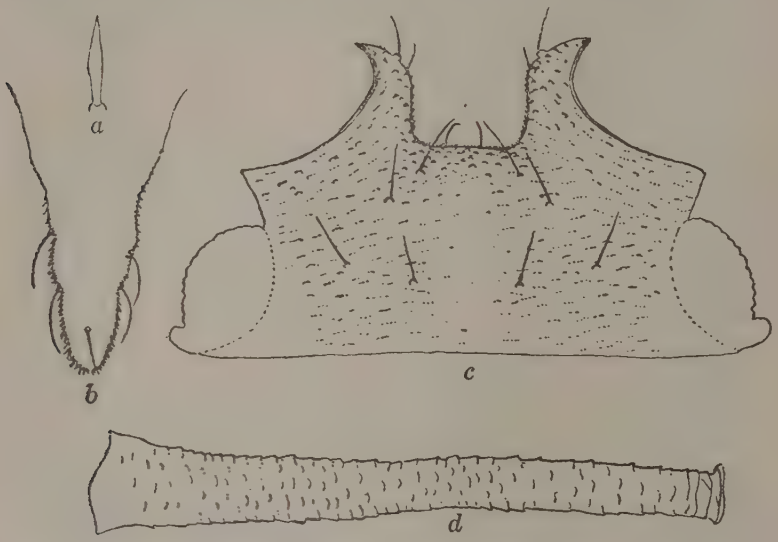

FIG. 1. *Acyrthosiphon kuwanai* sp. nov.; wingless viviparous female; *a*, dorsal setæ; *b*, cauda; *c*, head; *d*, cornicle.

setæ, which are also a little shorter than the setæ on the head. Cornicles very long, rather slender, expanded on the basal part, nearly straight, roughly imbricated, not reticulated, about six times as long as wide, about twice as long as the cauda, much shorter than the third antennal joint, with a flange at the tip. Cauda large, tapering gradually, about twice as long as wide, with two slight constrictions, two pairs of long curved lateral bristles, and a median one. Legs very long; coxæ imbricated, with some rather long stout setæ; femora long, with many short stiff setæ slightly capitate, and about eight to twelve small circular sensoria scattered on the basal part; tibiæ stouter than the

third antennal joint, on the basal part as stout as the distal part of cornicle, with many stout setæ, the setæ on the basal part slightly capitate; tarsi somewhat imbricated, much shorter than the basal part of the last antennal joint, the basal joint with two setæ on the distal part.

Length of body, about 1.5 to 1.8 millimeters; antenna, about 3; cornicle, about 0.508; cauda, about 0.245; hind femur, about 1.1; hind tibia, about 1.9; dorsal seta on head, about 0.046.

Host.—Vitis sp.

Habitat.—Rarasan (altitude about 6,700 feet), near Urai.

Some specimens were collected by the author July 31, 1933. This species is characterized by the peculiar setæ on the dorsum. Named in the memory of the late Dr. I. Kuwana, who has contributed to the study of the Aphididæ of Japan.

AKKAIA TAIWANA sp. nov.

Wingless viviparous female.—Slightly pale brownish white, somewhat shining. Antennæ, legs, and cauda similar in color, but slightly dusky on the tarsi. Cornicles jet black even in specimens treated with potash. Oval, broadest about the middle of abdomen, with a few minute dorsal setæ slightly capitate. Head with many small granules on the posterior part of dorsum, and six minute dorsal setæ somewhat capitate. Eyes distinctly protruding, with distinct ocular tubercles. Frontal tubercles large, not imbricated, lacking granules, with an eminent mesal tubercle, which is much longer than wide, rounded apically, not curved, reaching the middle of the first antennal joint, and with about four minute setæ expanded towards the tip. Antennæ much shorter than the body, distinctly imbricated on all the joints, five-jointed, with a few minute stout capitate setæ; the 1st joint wider than long, distinctly convex on the mesal side, a little protruding obtusely at the base of lateral side; the second somewhat shorter than the first but longer than the frontal tubercle, longer than wide, the third not imbricated on one side, slightly constricted near the distal end, lacking sensoria; the fourth on the distal part with a rather large circular sensorium which is not smooth on the surface; the relative length of joints about as follows: III—82, IV—25, V—20 + 40. Rostrum stout, reaching a little beyond the middle coxæ. Thorax with many spinules on the venter. Abdomen with numerous eminent dusky spinules in transverse rows behind each cornicle and on the last segment, and some very short simple setæ on the venter; abdominal segments not discernible, but the eighth segment defined, broadly

rounded on the hind margin. Cornicles large, very stout, a little curved, a little broadened towards the base, constricted on the apical part, stouter than the cauda, about thrice as long as wide, eminently imbricated, not reticulated, nearly as long as the third antennal joint, about 2.8 times as long as the cauda, directed posteriorly, with a distinct flange at the tip. Cauda large, stout,

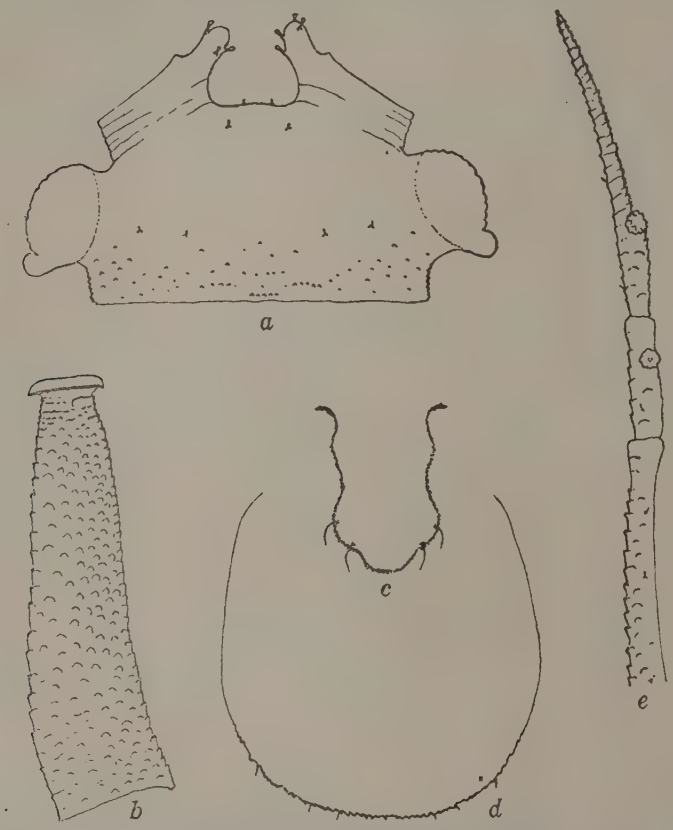

FIG. 2. *Akkaia taiwana* sp. nov.; wingless viviparous female; *a*, head; *b*, cornicle; *c*, cauda; *d*, genital plate; *e*, distal part of antenna.

about 1.6 times as long as wide, somewhat constricted at the base and the middle, a little expanded on the distal part, but a little narrowed on the apex, rounded apically, with two pairs of rather short fine lateral setæ. Anal plate rather large, a little protruding on the distal part, wide, broadly rounded apically, with six rather long setæ. Gonapophyses distinct, three in number. Genital plate extremely large, projecting posteriorly, rounded on

the side, broadly rounded on the hind margin, as long as wide, imbricated and with many spinules on the hind half, reaching beyond the middle of cauda, with a few small setæ on the hind margin. Legs long, slender, with some short setæ; tibiæ stouter than the third antennal joint; tarsi slightly striate, the basal joint with two setæ near the tip; hind tarsi as long as the basal part of the last antennal joint.

Length of body, about 1.8 millimeters; antenna, about 0.9; cornicle, about 0.4; cauda, about 0.14; anal plate, about 0.08; genital plate, about 0.29; hind femur, about 0.5; hind tibia, about 0.9.

Host.—*Polygonum* sp.

Habitat.—Ikenohata, Rato-Gun.

Many specimens were collected by the author August 1, 1933. This species differs from *Akkaia polygoni* Takahashi in the following characters: (*a*) The second antennal joint less protruding on the mesal side; (*b*) the distal part of the last antennal joint longer; (*c*) the frontal tubercles with a mesal tubercle not curved; (*d*) the abdomen wanting dorsal tubercles; (*e*) the cornicles jet black, shorter, not so much narrowed on the distal part; (*f*) the genital plate broadly rounded posteriorly.

GLYPHINAPHIS BAMBUSAE van der Goot.

Contr. Fauna Indes Neerland. 1, 3 (1917) 232; Tijdsch. Ent. 60 (1918) 113.

Host.—*Bambusa* sp., attacking the lower side of leaf.

Habitat.—Suisha.

Previously known from Java and Singapore. Two apterous females were taken by the author June 12, 1933. The specimens are different from the original description in the body being somewhat reddish brown and smaller, measuring about 1.5 millimeters in length, as well as in the fourth antennal joint being nearly as long as the third. These characters are variable in this group, and I regard the Formosan aphid as identical with this species. The apterous females are provided with numerous small poorly developed pores, irregular in outline, over the dorsum, and the marginal setæ are variable in length.

HAMAMELISTES TUBERCULATUS Takahashi.

Thoracaphis tuberculatus TAKAHASHI, Stylops 2 (1933) 30.

Winged viviparous female.—Head, antennæ, and thorax black. Legs gray. Abdomen pale greenish yellow. Wings fuscous, very slightly clouded along the obliques, with the stigma and veins gray. Body oblong. Head imbricated, with eight very

short setæ on the dorsum. Eyes large, with normal ocular tubercles. Front ocellus on a small protuberance on the front, which is narrow. Antennæ short, not striate, but constricted between the sensoria, four- or five-jointed, without eminent setæ; the first joint wider than long, nearly as long as the second; the third slightly longer than the front tibia, stouter than the basal part of it, with nine or ten linear sensoria in a row, which occupy nearly the entire circumference of the joint; the fourth with two to four similar sensoria; the fifth with two or three similar sensoria; the relative lengths of joints about as follows: III—41, IV—14, V—11 in the five-jointed antennæ, III—41, IV—20 in the four-jointed antennæ. Rostrum stout, the last

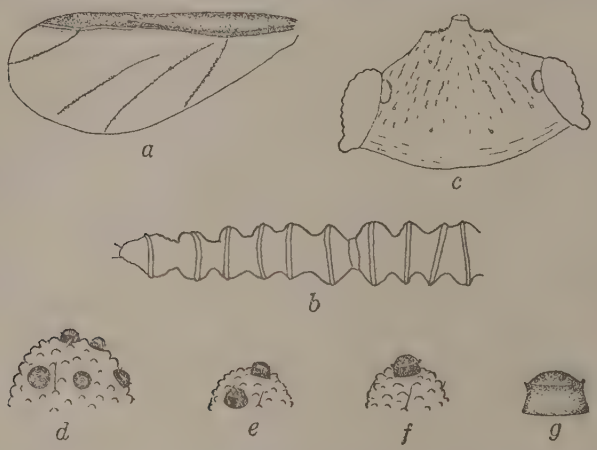

FIG. 3. *Hamamelistes tuberculatus* Takahashi, winged viviparous female; *a*, fore wing; *b*, distal part of antenna; *c*, head; nymph of winged viviparous female, *d*, *e*, *f*, dorsal tubercles; *g*, protuberance on dorsal tubercules.

joint slender, tapering, pointed at the tip, longer than the penultimate joint, not reaching the middle coxæ. Thorax without wax pores; mesonotum not divided into lobes, with a pair of very short setæ on the middle part. Abdomen with no setæ distinct. Cornicles small, very short, broadened toward the base, much wider than long. Cauda small, distinctly constricted, knobbed part somewhat wider than long, globular, a little wider than the apex of cornicle, with about six setæ. Anal plate bilobed, each lobe much wider than long, rounded, somewhat wider than the cauda, with about six setæ. Tibiæ a little broadened on the distal part, with many transverse rows of minute spinules, and a few short setæ on the distal part; hind tarsi nearly as long

as the last antennal joint, with two pairs of very long fine hairs somewhat capitate on the distal joint. Wings ample, imbricated, held horizontally in repose; the first oblique on the front wing slightly stouter than the second, slightly curved; the second slightly curved, not united with the first; the third obsolete on the basal part, not branched, very slightly curved; stigmatic vein slightly curved, nearly reaching the tip of wing; stigma normal; hind wings without obliques, hooklets two.

Length of body, about 1.15 millimeters; antenna, about 0.4; hind tibia, about 0.25; fore wing, about 1.5.

Nymph of winged viviparous female.—Pale yellow, with no secretion eminent. Dorsum covered with numerous very short rounded papillæ, and with many large rounded tubercles, which are wider than long, covered with many small papillæ similar to those on other parts of dorsum and with one to six short chitinized protuberances as shown in the figure; anterior dorsal tubercles larger than the posterior and lateral tubercles larger than the mesal, the number of these dorsal tubercles as follows: Head, a large pair; prothorax, a large one on the side and two small pairs on the median area; meso- and metathoracic and basal abdominal segments, four in a transverse row; the second and third abdominal segments, six in a transverse row; other abdominal segments, two to four; protuberances on the dorsal tubercles circular when seen from above, much wider than long, smaller in diameter than the apex of cornicle, rounded apically, pale brown in specimens treated with potash. Antennæ large, stout, three-jointed, without hairs.

Host.—*Quercus gilva,* attacking the lower side of leaf.

Habitat.—Taihoku, Sozan.

The aleyrodiform female was described as a *Thoracaphis* in the previous paper. Many winged forms and a few wingless ones were observed in January, 1933. This species differs from *Thoracaphis* in the following characters: (*a*) Antennæ not striate, but constricted between the sensoria in the winged form; (*b*) the third oblique (media) on the front wing not branched; (*c*) hind wings with no obliques; (*d*) cauda not constricted in the aleyrodiform female; (*e*) tarsi not segmented, without claws in the aleyrodiform female.

Referable to *Hamamelistes* Shimer, although differs from the typical forms of the genus.

(All the type specimens are kept in the collection of the Department of Agriculture, Government Research Institute, Formosa.)

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Acyrthosiphon kuwanai* sp. nov.; wingless viviparous female; *a*, dorsal seta; *b*, cauda; *c*, head; *d*, cornicle.

2. *Akkaia taiwana* sp. nov.; wingless viviparous female; *a*, head; *b*, cornicle; *c*, cauda; *d*, genital plate; *e*, distal part of antenna.

3. *Hamamelistes tuberculatus* Takahashi, winged viviparous female; *a*, fore wing; *b*, distal part of antenna; *c*, head; nymph of winged viviparous female, *d*, *e*, *f*, dorsal tubercles; *g*, protuberance on dorsal tubercles.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XVI[1]

By Charles P. Alexander

Of Amherst, Massachusetts

FOUR PLATES

The crane flies discussed herein are chiefly from eastern Siberia, where they were included in the very large and valuable collections belonging to the Russian Academy of Sciences, Leningrad, having been sent to me for determination through the kindly intervention of Drs. Theodore Pleske and A. von Stackelberg. All types resulting from this series are preserved in the collection of the Russian Academy. A few other specimens were taken in Szechwan, China, by Messrs. George M. Franck and David C. Graham, the types of the latter collector being contained in the United States National Museum, of the former in my own collection. I am greatly obliged to the above-mentioned scientists for their appreciated interest in sending me these specimens.

TIPULINÆ

TIPULA (TIPULA) STACKELBERGI sp. nov. Plate 1, fig. 1; Plate 2, fig. 25.

Belongs to the *tricolor* group, allied to *sulphurea;* general coloration gray, the præscutum with four brown stripes; mediotergite yellow, with a large light gray area on either side of median line; antennal segments beyond the third almost uniformly darkened; wings with a nearly uniform brownish yellow tinge, with no darker areas excepting the yellowish brown stigma; abdominal tergites yellowish, the outer segments, including hypopygium, more brownish black; male hypopygium with the tergal region produced into a triangular point at each outer angle; notch of ninth sternite with two small clavate lobes.

Male.—Length, about 14 millimeters; wing, 15.

Frontal prolongation of head yellowish white above, light brown on sides beneath; nasus distinct; palpi with basal seg-

[1] Contribution from the entomological laboratory, Massachusetts State College.

ment testaceous, the outer segments passing into dark brown. Antennæ broken at the ninth segment; relatively long, if complete extending about to base of abdomen or slightly beyond; scape and pedicel obscure yellow; first flagellar segment clear light yellow, the succeeding segments very vaguely bicolorous, the basal enlargement brownish black, the remainder of segment dark brown, outermost segments more uniformly brownish black; segments much longer than the verticils. Head light gray, with a capillary blackish median vitta.

Pronotum gray. Mesonotal præscutum light gray, with four brown stripes, the intermediate pair nearly contiguous, separated by a capillary blackish vitta; scutum light gray, the lobes variegated with more brownish gray; scutellum buffy, the color continued laterad along the posterior border of the scutal lobes to wing root; mediotergite yellow with a light gray area on either side of the median line, occupying about the distal three-fourths of the sclerite on either side of the midline; a very delicate impressed median line on distal third of mediotergite. Pleura with the anepisternum, sternopleurite, and meron clear light gray; posterior sclerites of pleura obscure yellow, sparsely pruinose, especially the pleurotergite; dorsopleural region light yellow. Halteres relatively long, the stem pale yellow, the knobs weakly darkened. Legs with the coxæ light gray pruinose, the posterior coxæ much paler, more yellowish gray; trochanters yellow; femora yellow, the tips narrowly blackened, the amount subequal on all legs; tibiæ brown, the tips darker; tarsi black. Wings (Plate 1, fig. 1) with an almost uniform brownish yellow tinge, the costal and prearcular regions brighter yellow; stigma pale yellowish brown; restricted obliterative areas before stigma and across base of cell 1st M_2; veins brown. Venation: Rs long, about two and one-half times m-cu; cell 1st M_2 long, parallel-sided; fork of M_{3+4} lying before level of r-m.

Abdominal tergites chiefly yellow, with scarcely darker more brownish yellow areas on sides; tergites with transverse blackened areas; outer segments, including hypopygium, brownish black. Male hypopygium with the caudal margin of tergite (Plate 2, fig. 25, 9*t*) terminating in two slender darkened lobes that are separated only by a linear slit, the apices of the lobes set with conspicuous blackened spicules; lateral angles of tergite further produced into subacute points. Ninth sternite, 9*s*, notched medially, at extreme base of incision with a pair of dusky clavate lobes that are densely covered with small setæ; these lobes do not jut caudad beyond the general level of the

sternite, as is the case in *sulphurea* Doane and *subsulphurea* sp. nov., but lie deep in the notch of the sternite. Inner dististyle, *id*, deeply bifid, the outer part more elongate and tipped with erect spines. Gonapophyses, *g*, appearing as pale spatulate blades with very slender stems.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, June 16, 1927 (*Stackelberg*), No. 81.

I take great pleasure in naming this very distinct crane fly in honor of the collector, Dr. A. von Stackelberg, custodian of the Diptera in the Russian Academy of Sciences. The nearest regional ally is *Tipula* (*Tipula*) *subsulphurea* sp. nov., which differs in the general coloration of the body, including the clear yellow mediotergite, darkened cubital seam, brightened hypopygium, and details of structure of the male hypopygium.

The reference of the species of the *tricolor* (*lateralis*) group to the typical subgenus may not prove to be justified. The members of the group as known form a compact unit that shows certain definite characters, as the short M_{3+4} and the paddlelike gonapophyses of the male hypopygium. In case these and other lesser characters are deemed sufficient to warrant a separate subgeneric term for the members of the group, the name *Yamatotipula* Matsumura (1916) is available.

TIPULA (TIPULA) SUBSULPHUREA sp. nov. Plate 1, fig. 2; Plate 2, fig. 26.

Belongs to the *tricolor* group, allied to *sulphurea;* antennæ (male) elongate, if bent backward extending to beyond base of abdomen; mesonotal præscutum light gray with four dark brown stripes; posterior sclerites of pleura, together with mediotergite, abruptly pale sulphur yellow; wings pale brownish yellow; a conspicuous brown seam along vein Cu; Rs elongate; cell 1st M_2 narrow; male hypopygium with the two lobes of the tergite slender, set with blackened points, separated by a deep and narrow median incision; ninth sternite slightly produced caudad on either side of midline into a slender fingerlike lobe that is tufted with setæ.

Male.—Length, about 12 millimeters; wing, 11; antenna alone, 4.

Female.—Length, about 16 millimeters; wing, 12.5; abdomen, 12.

Frontal prolongation of head brownish yellow to light yellow; nasus distinct; palpi dark brown. Antennæ (male) elongate, if bent backward extending to beyond the base of abdomen; basal

three segments yellow, succeeding two or three segments bicolorous, yellow, with the basal enlargement brownish black; outer segments more uniformly infuscated; flagellar segments elongate, much exceeding the small verticils. Head gray, the vertex with a capillary dark brown median line.

Pronotum dark gray. Mesonotal præscutum light gray, with four dark brown stripes; pseudosutural foveæ punctiform; scutum light gray, the lobes vaguely marked with darker; scutellum and mediotergite abruptly light yellow, the former a very little darker than the latter. Pleura with the anepisternum, sternopleurite, and ventral meral region light gray, the posterior sclerites of pleura, including pleurotergite, abruptly light sulphur yellow; dorsopleural membrane ocherous. Halteres dusky, the extreme base of stem yellow, the knobs dark brown. Legs with the fore and middle coxæ light gray, the posterior coxæ abruptly pale yellow; trochanters yellow; femora yellow, the tips narrowly blackened; tibiæ obscure yellow, infuscated on outer third, the tips blackened; tarsi black. Wings (Plate 1, fig. 2) pale brownish yellow, the prearcular and costal regions clearer yellow; stigma small, pale brown; a conspicuous brown seam occupies the space between the cubital branches, only vaguely crossing Cu_1 into posterior border of cell M; obliterative areas reduced to two small separated spots, one before stigma, the second across base of cell 1st M_2; veins brown, more yellowish in costal flavous areas. Venation: Rs long, nearly two and one-half times m-cu; cell 1st M_2 narrow; m-cu oblique, on M_4 just beyond the fork of the short M_{3+4}, the latter point lying proximad of level of r-m.

Abdominal tergites (male) yellow with a sublateral brown stripe on either side, the lateral margins of segments broadly yellow; hypopygium yellow; sternites yellow, very narrowly darkened laterally, the eighth sternite more uniformly darkened. In female, abdomen elongate; tergites darkened sublaterally, beyond the second segment so extensively so as to reduce the ground color to a narrow median line and pale margins. Male hypopygium (Plate 2, fig. 26) with the sclerites fused into a continuous ring. Ninth tergite, 9*t*, with the median region of caudal margin produced into a depressed lobe that is further extended into two lobes that are narrowly but deeply separated, densely set at tips with microscopic blackened points. Outer dististyle, *od*, a very short pale club, provided with long pale setæ. Inner dististyle, *id*, small, ear-shaped, with a darkened spinous lobe on face. Median region of sternite, 9*s*, delimited by sutures, each lateral angle produced slightly caudad into

a slender lobe that is tipped with a few long setæ. Eighth sternite unarmed.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Spassk, June 4, 1928 (*Obolenskij*), No. 591. Allotype, female, Maiche region, near Shkotovo, June 7, 1927 (*Sokolov*), No. 572.

The closest ally of the present fly appears to be *Tipula* (*Tipula*) *quadrivittata* Staeger, of northern Europe, which has a similar darkened cubital seam but may be readily told by the shorter male antennæ with the flagellum entirely blackened and with the scape and pedicel more or less suffused, together with differences in wing venation and in coloration of the posterior sclerites of the thorax, including both pleura and notum. The fly is likewise allied to *T.* (*T.*) *sulphurea* Doane, of northern North America, which differs in the shorter male antennæ, with more uniformly darkened flagellum, the barely indicated cubital darkening, and slight differences in structure of the male hypopygium.

TIPULA (TIPULA) MORIGERA sp. nov. Plate 1, fig. 3; Plate 2, fig. 27.

Belongs to the *tricolor* group, allied to *lateralis;* general coloration gray, the præscutum with four darker stripes that are narrowly bordered by dark brown; antennæ (male) moderately long, if bent backward extending to shortly beyond base of abdomen, the basal four or five segments pale, the remainder dark brown; pleura whitish; femora yellow, the tips narrowly blackened; wing pattern much as in *lateralis;* M_{3+4} very short to lacking; male hypopygium with the blades of the gonapophyses longer than wide.

Male.—Length, 12 to 13 millimeters; wing, 14 to 15; antenna, about 5.

Female.—Length, about 15 millimeters; wing, 14.

Frontal prolongation of head light yellow; nasus distinct; palpi black. Antennæ (male) relatively long, if bent backward extending to beyond base of abdomen; scape and pedicel light yellow, flagellar segments one to three a little more obscure yellow; suceeding segments passing into dark brown; flagellar segments moderately nodulose, the verticils shorter than the segments. Head light gray, the center of vertex more infuscated, the front pale.

Mesonotal præscutum gray with four darker gray to brown stripes that are narrowly bordered by dark brown, including a capillary median brown vitta; in cases the dark borders of

the stripes, with the exception of the median line, are obsolete or nearly so; scutum light gray, the lobes variegated by darker brownish gray areas; scutellum paler than mediotergite, both with a very delicate median brown line. Pleura whitish, the pleurotergite very pale yellow. Halteres yellow, the knobs dark brown. Legs with the coxæ whitish; trochanters yellow; femora yellow, the tips narrowly and conspicuously blackened; tibiæ brownish yellow, the tips blackened; tarsi black. Wings (Plate 1, fig. 3) tinged with brown, patterned about as in *eluta* or *lateralis;* prearcular region yellow; cell M and an obliterative area before cord more whitish; stigma, cell Sc, and seams on anterior cord and m-cu darker brown. Venation: M_{3+4} very short to obsolete, its maximum length about equal to R_2.

Abdominal tergites obscure yellow, with a very broad dark brown sublateral stripe, narrowly interrupted at caudal margins of segments; lateral borders of tergites broadly pale; sternites yellow, the subterminal segments darkened; hypopygium yellow. Male hypopygium with the median tergal plate (Plate 2, fig. 27, 9*t*) with a small U-shaped notch, the lateral lobes truncated and set with dense black setæ, these continued as a line down the ventral face of lobe. Outer dististyle, *od,* long, obtuse at tip, the posterior margin on basal half a little dilated. Inner dististyle, *id,* of characteristic shape, with a semicircular blackened armature at base of beak; group of sensory areas above this blackened collar numbering about 14 or 15; marginal fringe of setæ numerous, the outermost short and strongly curved. Setal brushes of ninth sternite in two separate groups. Gonapophyses *g,* with the blades longer than broad.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Kamen-Rybolov, Lake Chanka, July 8, 1927 (*Stackelberg*), No. 266. Allotype, female, Vladivostok, August 5, 1903 (*Gavronski*), No. 498. Paratopotype, male, July 8, 1927, No. 265. Paratypes, 1 male, Devitza station, Lake Chanka, July 14, 1927 (*Stackelberg*), No. 242; 4 females, Jakovlevka, Spassk district, August 31, 1926 (*Djakonov and Filippjev*), Nos. 115, 116, 125; September 12, 1926, No. 124; 1 male, Spassk, June 4, 1928 (*Obolenskij*).

In the elongate blades of the gonapophyses and nature of the ninth tergite of the male hypopygium, the present fly is closest to *Tipula* (*Tipula*) *couckei* Tonnoir (*gracilenta* Lackschewitz), of Europe, differing conspicuously in the structure of the outer dististyle, which is here more like that of the otherwise distinct *T.* (*T.*) *lateralis* Meigen. The pale basal segments of the fla-

gellum are as in *lateralis* and *montium* Egger, being entirely darkened in the other European members of the group, *cœrulescens* Lackschewitz, *couckei* Tonnoir, and *solstitialis* Westhoff.

TIPULA (TIPULA) PARVINCISA sp. nov. Plate 2, fig. 28.

Belongs to the *tricolor* group, allied to *lateralis;* general coloration of præscutum blue-gray, with four slightly darker gray stripes that are narrowly bordered by bright brown; antennæ (male) moderately long, if bent backward extending to slightly beyond base of abdomen; basal three segments obscure brownish yellow, the succeeding segments dark brown; wings pale yellowish white, cells C and Sc, stigma, and seams on m-cu and distal section of vein Cu_1 darker brown; abdominal tergites with sublateral brown stripes that are narrowly cross-connected before caudal margins; male hypopygium with the median notch of tergite very small, the lateral lobes lacking; blades of gonapophyses broader than long, the stem slender.

Male.—Length, 12 to 14 millimeters; wing, 14.5 to 16.5; antenna, about 5.

Female.—Length, about 18 to 19 millimeters; wing, 18; antenna, about 2.5.

Frontal prolongation of head above light gray pruinose, darker on sides beneath; palpi brownish black. Antennæ of male moderately long, if bent backward extending to shortly beyond the base of abdomen; basal three or four segments obscure brownish yellow, succeeding segments black; flagellar segments strongly incised, with verticils that are shorter than the segments; antennæ of female short, the basal seven or eight segments pale, the outer ones darkened; segments very weakly incised to subcylindrical. Head light blue-gray, with a capillary blackish median vitta.

Mesonotal præscutum with ground color light blue-gray, with four slightly darker gray stripes that are narrowly bordered by bright brown, the intermediate pair on outer margin sending a small spur toward the pseudosutural foveæ; scutum light gray, each lobe with two darker gray areas; posterior sclerites of mesonotum light gray, with vague indications of a capillary darker line. The paratopotype has the median præscutal vitta unusually distinct. Pleura clear light gray; dorsopleural membrane pale yellow. Halteres with stem yellow, knobs darkened. Legs with the coxæ whitish gray; trochanters yellow; femora yellow, the tips blackened; tibiæ obscure yellow, the tips more broadly blackened; tarsi black. Wings with the ground color pale yellowish white; cells C and Sc with stigma infuscated; broad and

conspicuous brown seams on anterior cord, m-cu, and distal section of Cu_1; a conspicuous pale yellow antestigmal area in cell C; veins brown.

Abdominal tergites with the dorsomedian line ocherous, sparsely pruinose; sublateral stripes broad, on intermediate and outer segments narrowly connected before caudal margins of segments; lateral borders of tergites broadly pale, the caudal margins narrowly so; sternites pale, the subterminal segments infuscated. Male hypopygium with the median plate of tergite (Plate 2, fig. 28, 9*t*) broad, its margin convexly rounded, with a small U-shaped median incision. Outer dististyle, *od*, small, obtusely rounded at tip, the cephalic border near base with long coarse black setæ. Inner dististyle, *id*, with the terminal beaklike portion unusually broad and flattened, the apex obtusely truncated. Gonapophyses, *g*, with the stem long and slender, the blade broader than long. Hair brushes of ninth sternite in four distinct groups.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, June 9, 1927 (*Stackelberg*), No. 53. Allotopotype, female, June 16, 1927, No. 80. Paratopotype, male, June 9, 1927, No. 54. Paratypes, 1 male, 1 female, Jakovlevka, Spassk district, September 4, 1926 (*Djakonov and Filippjev*), Nos. 123, 176; 1 female, Vladivostok, July 16, 1903 (*Gavronsky*); 1 female, Tiger Mountain, Vladivostok, July 21, 1912 (*Sycheff*), No. 694; 1 female, Maiche region, near Shkotovo, June 4, 1927 (*Sokolov*), No. 576.

The present fly differs conspicuously from *Tipula* (*Tipula*) *morigera* sp. nov. in the structure of the male hypopygium, as shown by the comparative figures. The species is similarly quite distinct in the structure of the male hypopygium from the European *T.* (*T.*) *lateralis* Meigen and *T.* (*T.*) *montium* Egger, which likewise have the basal segments of the flagellum pale. The paratypes have the præscutal stripes more brownish gray and the ground color of the wings more infumed, but certainly appear to belong here.

TIPULA (TIPULA) PROTRUSA sp. nov. Plate 1, fig. 4; Plate 2, fig. 29.

Belongs to the *tricolor* group, allied to *aino;* general coloration gray, the præscutum with four grayish brown stripes that are narrowly bordered by darker brown; antennæ short, scape and pedicel brownish black, the former a little reddish at base; basal flagellar segments with the proximal ends reddish, remainder of organ black; wings strongly infumed, with a conspicuous obliterative area before cord; outer radial cells unbright-

ened; abdominal tergites unequally trivittate with dark brown; male hypopygium with the tergite produced into a median black plate that is convexly rounded above to appear more or less like a portion of a cylinder.

Male.—Length, 23 to 25 millimeters; wing, 20 to 22; antenna, 3 to 3.3.

Female.—Length, about 25 millimeters; wing, 22 to 23.

Frontal prolongation of head relatively short, reddish brown, pruinose above; palpi black. Antennæ short, if bent backward not attaining the wing root; scape and pedicel brownish black, the former a little reddish at base; first flagellar segment reddish, the succeeding segments black, with the basal enlargements of the proximal segments a little reddish; flagellar segments short and crowded, the verticils subequal to or exceeding the segments. Head gray, the region of the vertical tubercle with a median impressed line.

Mesonotal præscutum gray, with four grayish brown stripes that are narrowly bordered by darker brown, the mesal edges of intermediate stripes a little divided at near midlength to expose a strip of the ground color; scutum blackish gray, the mesal portion of each scutal lobe paler; scutellum brownish gray, bordered by reddish; in cases the scutellum more uniformly gray, with a weak median brown line; mediotergite clear light gray. Pleura with the anterior sclerites clear light gray, the posterior sclerites light yellow, the latter including the pteropleurite, excepting a gray spur at dorsocephalic angle, the dorsal meron, base of halteres, and a stripe across the pleurotergite; dorsopleural membrane more buffy yellow. Halteres pale, the knobs dark brown. Legs with the coxæ light gray, the posterior coxæ a little brightened at bases; trochanters yellow; femora and tibiæ yellow, the tips narrowly black; tarsi black. Wings (Plate 1, fig. 4) strongly infumed, the stigma and costal region somewhat darker; proximal end of stigma yellow; anterior and posterior cord narrowly bordered with brown; obliterative streak before cord conspicuous, extending from before stigma into extreme base of cell M_3; no evidence of paling in outer radial cells, as is the case in *aino;* bases of anal cells a little brightened; veins dark. Venation: Rs from two and one-half to three times m-cu; M_{3+4} from one-third to nearly one-half the basal section of M_3; petiole of cell M_1 about one-half m.

Abdominal tergites broadly buffy dorsomedially, with a broken pale brown median vitta, broadly broken on basal ring, more narrowly so at caudal border of each segment; sublateral stripes

darker and more nearly continuous; lateral margins of segments broadly pale; tergal plate of hypopygium dark basally, more reddish outwardly, the median lobe polished black; basal sternites chiefly pale, the subterminal segments heavily gray pruinose. Male hypopygium with the region of tergite (Plate 2, fig. 29, 9*t*) produced medially into a relatively narrow, heavily blackened plate that is convexly arched or rounded so as to appear somewhat like a portion of a cylinder; apex of lobe with a small notch, the lobes thus formed truncated, their outer angles acute; the figure shows the tergal lobe as being more or less flattened and indicates obtuse lateral shoulders. Outer dististyle, *od,* pale, obtuse at apex, the outer margin dilated near base. Inner dististyle, *id,* very complex in structure; on mesal face a sclerotized plate that bears a comb of long reddish spines that are unequally tridentate at tips.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Jakovlevka, Spassk district, June 25, 1927 (*A. Martynov*), No. 214. Allotype, female, in poor condition, Tigrovaja, Suchan district, June 11, 1927 (*Stackelberg*), No. 5. Paratypes, 1 broken male, with allotype, June 8, 1927, No. 59: 1 male, Sedanka River, near Vladivostok, April 20, 1927 (*Martynov*), No. 191; 1 male, Ugodinza River, near Jakovlevka, July 4, 1927 (*Martynov and Rezvoj*), No. 583.

The nearest regional ally of the present fly is *Tipula* (*Tipula*) *aino* Alexander (Japan to Ussuri), which is well-distinguished by the more elongate antennæ, with the basal segments pale, the increased amount of white on the wings, and, especially, the structure of the male hypopygium, notably of the tergal plate.

TIPULA (VESTIPLEX) TUMULTA sp. nov. Plate 1, fig. 5; Plate 2, fig. 30.

Allied to *grahami;* size smaller (wing, male, less than 20 millimeters); mesonotal præscutum dull gray, with four brown stripes, the median line narrowly dark brown; apices of knobs of halteres pale; femora yellow, the tips narrowly black; wings pale brown, variegated by darker brown and whitish areas; basal abdominal segments yellow, narrowly trivittate with dark brown; terminal segments black; male hypopygium with the tergite divided; basistyle with an acute spine.

Male.—Length, about 17 millimeters; wing, 19.5.

Frontal prolongation of head light brown; nasus stout; palpi brown. Antennæ relatively short, ending before wing root; basal four segments obscure yellow, succeeding segments weakly bicolorous, the basal enlargements brown, the remainder brown-

ish yellow; outer segments more uniformly darkened. Head buffy, with a conspicuous brown median line on vertex.

Mesonotal præscutum dull gray, with four brown stripes that are only narrowly and insensibly bordered by darker; a median capillary dark brown line; scutellum grayish yellow, with a median brown line; mediotergite grayish yellow. Pleura chiefly destroyed by crushing, apparently extensively gray. Halteres brownish yellow, the knobs dark brown with pale apices. Legs with the coxæ brownish gray; trochanters yellow; femora yellow, the tips narrowly but conspicuously black; bases of tibiæ obscure yellow, the apices and all tarsi broken. Wings (Plate 1, fig. 5) with the ground color pale brown, variegated by darker brown and whitish areas; prearcular and costal regions light yellow; the darker brown markings include a conspicuous area in the bases of cells R and M, the stigma and a confluent spot on anterior cord, origin of Rs and narrow seams on m-cu and outer end of vein Cu_1; the pale areas are distinctly less yellowish than in *grahami*, being whitish subhyaline, including the axillary region, a broad and nearly complete fascia at near one-third the wing length; other similar areas before stigma, near outer end of cell M and in outer end of cell 1st A; a broad, incomplete, pale crossband beyond cord, extending into base of cell M_3; veins brown, more yellowish in the costal region. Venation: Rs exceeding twice the length of m-cu; vein R_3 gently upcurved at tip, not extended outwardly as in *grahami*, cells R_2 and R_3 at margin being subequal in extent.

Abdomen with the basal segments yellow, the tergites with a median brown line that is narrowly interrupted at the sutures; basal tergites with a similar narrow dark brown sublateral stripe that becomes obsolete beyond the second segment; extreme lateral borders of tergites grayish; segments seven to nine, inclusive, black. Male hypopygium much as in *grahami*. Spines of ninth tergite slender, straight, the surface microscopically roughened. Spine of basistyle, *b*, slender, narrowed to the acute tip. Inner dististyle as shown (Plate 2, fig. 30, *id*).

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet (*Graham*).

The nearest ally is *Tipula* (*Vestiplex*) *grahami* Alexander (China-Tibet border) which differs especially in the large size and more yellowish areas of the wing disk. The details of the male hypopygium are slightly different in the two flies, yet so similar as to indicate a close relationship.

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TIPULA (VESTIPLEX) JAKUT sp. nov. Plate 1, fig. 6.

General coloration gray, the præscutum with four darker gray stripes that are narrowly bordered by brown; legs relatively short and stout, femora yellowish brown, the tips weakly darkened; wings pale brown, variegated by whitish areas, including all of cells beyond cord excepting the outer radial field; outer medial field pale; m-cu on M_4 some distance beyond origin; abdomen broadly depressed, the tergites obscure yellow, trivittate with dark brown.

Female.—Length, about 22 millimeters; wing, 16.5; hind leg, femur, 7; tibia, 8.8; tarsus, 6.5.

Frontal prolongation of head gray; nasus distinct; palpi dark brown. Antennæ with basal segments obscure yellow, the outer segments darker; outer flagellar segments short and crowded; basal enlargements scarcely developed; verticils a little longer than the segments; terminal segment long. Head light gray; vertical tubercle lacking.

Mesonotal præscutum gray, with four darker gray stripes that are narrowly bordered by brown; interspaces with erect pale setæ; scutal lobes chiefly darkened; posterior sclerites of mesonotum gray. Pleura gray, the dorsopleural region more buffy. Halteres pale, the knobs darkened. Legs with the coxæ pale gray; trochanters reddish yellow; remainder of legs relatively short and stout; femora and tibiæ yellowish brown, their tips weakly darkened; tarsi passing to brownish black. Wings (Plate 1, fig. 6) pale brown, variegated with whitish areas, the ground color including the basal third of wing; stigma a little darker than the ground; the pale areas include the cells beyond cord, excepting the outer half of radial field which is darkened; cell M dark except for a white spot opposite origin of Rs; outer ends of cells Cu and 1st A white, the bases darkened; cell 2d A entirely darkened, veins pale brown. Macrotrichia of veins beyond cord very small and sparse; a scattered series on outer two-thirds of R_{4+5}; M_1, M_2, and M_3 with only a few small trichia; other veins beyond cord glabrous. Venation: Cell M_1 long-petiolate; m-cu on M_4 a considerable distance beyond base; M_{3+4} less than one-half basal section of M_3.

Abdomen broad, depressed, the genital segment abruptly narrowed; ground color of tergites obscure yellow, broadly trivittate with dark brown, the median stripe narrower and more interrupted than the sublaterals; caudal margins of intermediate and outer tergites narrowly pale yellow; sternites reddish brown, sparsely pruinose, the caudal margins of the segments yellow;

dorsal shield of ovipositor blackened; cerci with ill-defined and obtuse teeth, interspersed with setæ.

Habitat.—Eastern Asia (Jakutsk).

Holotype, female, between Ajan and Nelkan, valley of the Tongi River, 137° 30′ east longitude, 56° 40′ north latitude, June 9 to 15, 1903 (*Popov*), No. 442.

The present fly is well distinguished from the other described regional species of *Vestiplex* by the wing pattern, in conjunction with the venation and the depressed abdomen. The latter condition strongly suggests the condition found in certain species of the *besselsi* group occupying this same general region.

TIPULA (ACUTIPULA) OMEIENSIS sp. nov. Plate 1, fig. 7; Plate 2, fig. 31.

General coloration of thorax clear gray, without greenish or olive tints; mesonotal præscutum with four narrow brown stripes, the intermediate pair obsolete in front; femora extensively blackened; wings brown, with broad and conspicuous pale areas along cord and across bases of outer medial cells; male hypopygium with apex of outer lobe of inner dististyle produced at apex into a slender spine.

Male.—Length, about 14 millimeters; wing, 16.5.

Female.—Length, about 21 millimeters; wing, 19.5.

Frontal prolongation of head above reddish yellow, sparsely pruinose, darkened ventrolaterally; nasus stout; palpi black. Antennæ with the scape and pedicel yellow; flagellum black, the first segment brightened at extreme base; verticils of moderate length only, subequal to the segments. Head dark gray.

Mesonotum clear light gray, with no signs of olive or greenish suffusions; præscutum with four narrow brown stripes, the intermediate pair obsolete on cephalic fourth or fifth of sclerite, separated by a median line of the ground color that is subequal to or wider than one stripe; lateral stripes diffuse, best indicated by a slightly darker mesal edge; scutal lobes with darkened areas. Pleura gray; dorsopleural membrane buffy. Halteres black. Legs with the coxæ gray; trochanters yellow; femora of male yellow basally, the tips broadly blackened, the proximal fifth or sixth being brightened; in female, the posterior and middle femora obscure yellow with the tips more narrowly darkened, especially of the hind legs; tibiæ and tarsi brownish black to black. Wings (Plate 1, fig. 7) with a strong brown tinge, the prearcular and costal regions somewhat more brownish yellow; cell Cu on either side of the darkened area and a spot near outer end of cell M light yellow; a distinct, more whitish, obli-

terative area extending from before the stigma deep into cell M_4, with a continuous brightening that involves the bases of cells M_1, 2d M_2, and M_3, together with the extreme adjoining portion of cell R_5; stigma brown; veins brown. Venation: Rs a little exceeding m-cu, especially in female.

Abdomen with the basal four tergites obscure yellow, trivittate with brown, the remaining segments, including hypopygium, more uniformly darkened; basal sternites yellow. Male hypopygium with the median lobe of tergite entire, set with abundant blackened spicules. Dististyle as shown (Plate 2, fig. 31, *id, od*): Setæ at vertex of inner style very abundant, forty to fifty in number; apex of style produced into a slender spine, with approximately fifteen pendant setæ at and near this spine. Eighth sternite medially not produced into a lobe but provided with abundant long erect yellow setæ.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 11,000 feet, July 19, 1931 (*Franck*). Allotopotype, female, July 18, 1931.

The nearest ally of this fly is *Tipula* (*Acutipula*) *atuntzuensis* Edwards (Yunnan), which differs in the more greenish gray coloration of the head and mesonotum, the distinct nature of the præscutal stripes, and the wing pattern. In the present fly, the outer pale band is very conspicuous, extending from cells R_5 to M_4, inclusive.

TIPULA (ACUTIPULA) VANA sp. nov. Plate 1, fig. 8; Plate 2, fig. 32.

General coloration yellow to pale brown, the præscutum with four brown or reddish brown stripes; pleura yellow; femora yellow, the tips narrowly and weakly darkened; wings with the ground color yellowish, the usual dark pattern relatively pale and ill-defined; spot in cell Cu present; male hypopygium with the median lobe of tergite relatively broad and depressed; eighth sternite at apex produced into a small tubercle, the median region behind this with long erect pale setæ.

Male.—Length, 14 to 15 millimeters; wing, 14.5 to 15.

Female.—Length, 22 to 24 millimeters; wing, 17 to 18.

Frontal prolongation of head light brown; nasus distinct. Antennæ varying from almost uniformly pale yellow to light brownish yellow, with the outer segments passing into brown. Head brownish gray.

Pronotum yellow. Mesonotal præscutum light brown, sparsely pruinose, with four darker brown stripes; in the paratype, the mesonotum has a pale yellow ground, with four more reddish

brown stripes; scutum with lobes variegated with reddish brown to pale brown; posterior sclerites of mesonotum chiefly pale. Pleura yellow. Halteres pale yellow, the knobs weakly darkened. Legs with the coxæ and trochanters yellow; femora yellow, the tips narrowly and rather weakly darkened; tibiæ yellow, the tips narrowly darkened; tarsi passing into brown. Wings (Plate 1, fig. 8) with a yellow or pale brownish yellow ground, the prearcular and costal regions light yellow; stigma pale brown; bases of outer radial cells weakly darkened; outer end of cell M and the spot in cell Cu pale brown, relatively indistinct; obliterative band narrow, extending from before stigma into base of cell M_3; veins brown, yellow in the flavous areas. Macrotrichia relatively numerous on veins beyond cord; R_{1+2} with a few trichia near base, in cases almost destitute of same. Venation: Rs and m-cu subequal in length.

Abdomen yellow, the basal tergites narrowly darkened sublaterally; segment five and succeeding segments more uniformly darkened, the caudal margins of segments, especially of the sternites, narrowly but conspicuously ringed with pale. Male hypopygium with the median lobe of tergite (Plate 2, fig. 32, 9*t*) as viewed from above relatively broad and depressed, the apex weakly notched, set with blackened spicules. Outer dististyle pale, narrowed at base, with scattered pale setæ only, with no group of elongate setæ near base, as in *kuzuensis*. Inner dististyle, *id*, with the outer lobe extended into an acute spinous point, before which, on lower face, is a series of about fifteen spines; vertex or crown of style with about forty long erect coarse setæ. Eighth sternite, 8*s*, very moderately sheathing, the apex at midline produced into a small erect to slightly retrorse tubercle that is nearly naked; immediately behind this, the median region of sternite for more than one-half the entire length bears a fringe of long erect pale setæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Slavianski Bay, Tulamu River, July 12, 1911 (*Rydzevski and Kuznetzov*), No. 436. Allotopotype, female, with type, No. 437. Paratopotype, male, with type, No. 438; paratype, 1 female, Vladivostok, June 20, 1903 (*Gavronski*), No. 502.

In the unusually pale pattern of the wings, the present fly somewhat resembles the larger *Tipula* (*Acutipula*) *kuzuensis* Alexander, of Japan, which differs in several important features of the male hypopygium, such as the differently shaped outer dististyle, with a brush of elongate setæ on outer margin near base; the obtusely rounded apex of the outer lobe of the inner

dististyle; and the lack of a median tubercle on the eighth sternite. This last peculiar feature serves to separate the present fly from other regional generally similar species of *Acutipula*.

TIPULA (ACUTIPULA) COCKERELLIANA Alexander. Plate 3, fig. 33.

Tipula cockerelliana ALEXANDER, Proc. U. S. Nat. Mus. 68, art. 4 (1925) 14–15.

Described from a single female, taken at Okeanskaja station, near Vladivostok, Ussuri, in August, 1923, by Prof. T. D. A. Cockerell. A few additional specimens now available show that the species is very distinct from all other generally similar described forms.

Okeanskaja, July 27, 1911 (*Shavinskaja*), No. 412; July 31, 1911, No. 410; August 6, 1911, No. 411. Tiger Mountain, Vladivostok, July 21, 1912 (*Sycheff*), No. 692.

The single male from the above series is described as allotype.

Male.—Length, about 20 millimeters; wing, 20.

Characters as in the female, with but few exceptions. Obliterative streak of wing less conspicuous than in type female, but still of unusual width and distinctness. Abdominal segments beyond the third strongly darkened. Male hypopygium with the outer dististyle (Plate 3, fig. 33, *od*) large, narrowed to the subacute apex, the margin, especially near the base, with long conspicuous setæ, those on outer margin before apex very small and sparse; setæ of disk very few and scattered, as is common in the subgenus. Inner dististyle, *id*, as shown; crown or vertex of style with forty or more erect coarse setæ; outer lobe produced at apex into an acute spine that is surrounded by other slightly shorter, more-appressed setæ of similar coarseness; lower lobe or beak blackened, simple. Eighth sternite produced medially and bearing a dense fringe of long yellow setæ that become smaller back from margin.

Allotype.—Okeanskaja station, July 27, 1911 (*Shavinskaja*), No. 412.

The superficial resemblance of this fly to *Tipula* (*Acutipula*) *acanthophora* sp. nov. is surprisingly close, but there is no question of the distinctness and validity of both species.

TIPULA (ACUTIPULA) ACANTHOPHORA sp. nov. Plate 1, fig. 9; Plate 3, fig. 34.

Allied to *Tipula* (*Acutipula*) *cockerelliana;* antennæ relatively short, bicolorous; præscutum gray with four very slightly darker gray stripes; wings pale yellow, with a dark and whitish pattern; obliterative streak broad; pale area across bases of outer median cells not or scarcely entering cell R_5; dark spot in cell

Cu conspicuous; cell 1st M_2 relatively small; male hypopygium with the median lobe of tergite simple, unusually slender; inner dististyle with the outer lobe produced into a long slender spine; eighth sternite with short inconspicuous setæ.

Male.—Length, 17 to 19 millimeters; wing, 20 to 21.

Female.—Length, 22 to 28 millimeters; wing, 20 to 23.

Frontal prolongation of head light brown; nasus conspicuous; palpi brown. Antennæ (male) of moderate length, if bent backward extending to mid-distance between bases of wings and halteres; basal three segments yellow, the remainder bicolorous, chiefly yellow, with the small basal enlargements infuscated; verticils long. Head gray; anterior vertex with a narrow brown line.

Pronotum yellow. Mesonotum light gray, the præscutum with four very slightly darker gray stripes; centers of scutal lobes similarly darkened. Pleura light yellow, the dorsopleural region more buffy. Halteres pale, the bases of knobs dark brown, the tips restrictedly pale. Legs yellow, the tips of femora narrowly brown, of tibiæ even more narrowly infuscated; terminal tarsal segments infuscated. Wings (Plate 1, fig. 9) with the ground color pale yellow, the prearcular and costal regions more saturated yellow; bases of outer radial cells, outer half of cell 1st M_2, and outer end of cell M more darkened; dark spot in cell Cu conspicuous; obliterative streak broad and conspicuous, extending deep into cell M_3 and including the narrow outer border of cell M_4; pale band across bases of outer medial cells not or scarcely invading cell R_5; veins brown, yellow in the flavous areas. Venation: Rs a little longer than m-cu; cell 1st M_2 smaller than in *cockerelliana.*

Abdomen yellow, the outer abdominal segments weakly infumed; basal tergites with scarcely indicated pale brown sublateral stripes. Male hypopygium with the apical point of tergite (Plate 3, fig. 34, 9*t*) unusually slender, simple. Outer dististyle much smaller than in *cockerelliana.* Inner dististyle, *id,* with the outer lobe produced into a slender acute spine; basal lobe compressed, the apex weakly emarginate, the more basal point or beak blackened; crown or vertex of style with approximately eighteen to twenty coarse spinous setæ. Eighth sternite not produced, with short inconspicuous setæ only.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, August 2, 1927 (*Stackelberg*), No. 6. Allotopotype, female, August 2, 1927, No. 48. Paratopotype, male, August 4 or 5, 1927, No. 83; para-

types, 2 males, Sidemi, July 19, 1897, No. 483; August 18, 1897, No. 451 (*Jankovski*); 1 female, Okeanskaja station, near Vladivostok, July 31, 1911 (*Shavinskaja*), No. 409; 1 female, Kedrovaja Padj, Posjet district, southwest of Vladivostok, June 15, 1926 (*Mordvilko*), No. 616; 1 female, same as last, August 5, 1927 (*Rezvoj*), No. 596.

In its general appearance, the present fly is very similar to *Tipula* (*Acutipula*) *cockerelliana* Alexander, differing most evidently in the structure of the male hypopygium, notably the smaller, less hairy outer dististyle, the acute outer spine of the inner dististyle, and the much shorter and inconspicuous setæ of the eighth sternite. The pale ground color of the wings is less yellowish and the area across the bases of the outer medial cells scarcely invades cell R_5.

TIPULA (LUNATIPULA) VALIDICORNIS sp. nov. Plate 1, fig. 10; Plate 3, figs. 35 to 37.

Belongs to the *fascipennis* group; size large (wing, over 18 millimeters); general coloration of mesonotum yellowish gray, the præscutum with four dark gray stripes; legs yellow, the tips of femora and tibiæ undarkened; wings grayish yellow, the obliterative area very conspicuous; male hypopygium large, the lateral angles of tergite produced caudad into powerful horns; inner dististyle a very narrow blade that is produced into a long spine; eighth sternite sheathing, each lateral angle produced into a tubercle that is tipped with a long reddish spine.

Male.—Length, about 17 to 18 millimeters; wing, 19 to 20.

Female.—Length, about 16 millimeters; wing, 19.

Male.—Frontal prolongation of head brownish yellow, the sides on ventral half somewhat darker; nasus short and stout, with a tuft of long yellow setæ; palpi pale brownish yellow, the terminal segment dark brown. Antennæ moderately long, if bent backward extending to shortly beyond base of abdomen; basal three segments yellow, the outer flagellar segments passing into brown; flagellar segments moderately incised, a little shorter than the longest verticils. Head gray.

Mesonotal præscutum yellowish gray, with four dark gray stripes, the intermediate pair narrowed behind; interspaces with conspicuous yellow setæ; scutal lobes chiefly dark gray; posterior sclerites of mesonotum yellowish gray. Pleura chiefly pale yellow, the ventral anepisternum and ventral sternopleurite gray; dorsopleural region light yellow. Halteres pale, the knobs darkened. Legs with the coxæ yellow, very sparsely pruinose; trochanters yellow; femora and tibiæ obscure yellow, the tips

undarkened; tarsi obscure yellow, passing into black. Wings (Plate 1, fig. 10) with the ground color grayish yellow, the prearcular and costal regions, together with cell Cu, clear light yellow; stigma bicolorous, the proximal end yellow, the outer portion brown; outer radial field slightly infumed; narrow dusky clouds on m-cu and distal section of vein Cu_1; a very conspicuous obliterative streak extending from before stigma across cell 1st M_2 almost to wing margin in cells M_3 and M_4, the veins traversed, especially the anterior cord, unusually pale and indistinct; veins brown, more yellowish in the flavous areas. Venation: Cell 1st M_2 slightly more elongate than in the group.

Abdominal tergites yellow, the outer segments, including the hypopygium, more yellowish brown to brown; no distinct stripes on abdomen. Male hypopygium (Plate 3, fig. 35) large and conspicuous; tergite, 9*t*, and eighth sternite, 8*s*, large, the basistyle and ninth sternite, 9*s*, correspondingly reduced; suture between tergite and sternite only faintly indicated. Ninth tergite (Plate 3, fig. 36, 9*t*) with each lateral angle produced caudad into a powerful reddish horn, the tip flattened and deflected slightly laterad; base of horn with conspicuous yellow setæ. Basistyle not separated from sternite. Outer dististyle, a tiny lobe, with very long conspicuous setæ. Inner dististyle, *id*, a narrow sclerotized blade that is extended into a slender acute point. Eighth sternite (Plate 3, fig. 36, 8*s*) large, the eighth tergite correspondingly reduced; sternite sheathing, each lateral angle of caudal margin produced into a lobe that is tipped with a long reddish spine, these spines decussate across the midline; midventral region of sternite, between lobes, with a brush or fringe of long yellow setæ.

Female.—Characters as in male, differing in sexual features only. Antennæ short, if bent backward scarcely attaining the wing root. Abdominal tergites with a broken median brown line, the sixth and succeeding segments chiefly darkened; sternites pale. Ovipositor with all valves, including cerci, short and blunt (Plate 3, fig. 37, *c*).

Habitat.—Eastern Siberia (Amur, Ussuri).

Holotype, male, Sedanka River, near Vladivostok, Ussuri, April 20, 1927 (*Martynov*), No. 197. Allotopotype, female, with type, No. 196. Paratopotype, male, with type, No. 198. Paratypes, 1 male, Tigrovaja, Suchan district, Ussuri, June 16, 1927 (*Stackelberg*), No. 85; 1 male, Osernaja, mouth of Amur River, June 26 to 28, 1915 (*Chernavin*), No. 711.

The present fly is very distinct from all other Holarctic members of the *fascipennis* (*bicornis*) group in the major size and details of structure of the male hypopygium. The fly is most similar to species such as *affinis* Schummel (Europe) or *bicornis* Forbes, *megaura* Doane, or *parshleyi* Alexander (northeastern North America), but the powerful tergal horns are quite different in position, shape, and direction from the horns of all other described species of the group. It would appear that a new subgeneric group will eventually be required for the members of the group, to be based primarily on the structure of the ovipositor.

TIPULA (LUNATIPULA) PSEUDOGYNE sp. nov. Plate 1, fig. 11; Plate 3, fig. 38.

Belongs to the *fascipennis* group; general coloration gray; antennæ with scape and pedicel yellow, flagellum black; femora yellow, the tips narrowly blackened; wings pale grayish yellow, the costal region clearer yellow; R_{1+2} entire; cell 1st M_2 small; m-cu on M_{3+4} before fork; ovipositor with unusually short cerci, the genital chamber open.

Female.—Length, about 12 millimeters; wing, 12.5.

Frontal prolongation of head relatively short, brown; nasus short and stout; palpi light brown, the terminal segment dark brown. Antennæ with the scape obscure yellow, weakly darkened at base; pedicel light yellow; flagellum black, the basal enlargements poorly defined, the verticils subequal in length to the segments. Head dark brownish gray, the occipital region a little brighter; the area surrounding antennal fossæ pale.

Mesonotum gray, the præscutum without well-defined darker stripes. Pleura gray pruinose, the dorsopleural membrane ocherous. Halteres pale, the knobs weakly infuscated. Legs with the coxæ light gray pruinose; trochanters obscure yellow; femora yellow, the tips narrowly blackened; tibiæ and basitarsi testaceous brown, the outer tarsal segments blackened; tibial spur formula ?–2–2, the fore tibiæ broken. Wings (Plate 1, fig. 11) pale grayish yellow, the prearcular and costal regions clearer yellow; stigma small, pale brown; obliterative areas not conspicuous, lying before stigma and across cell 1st M_2; veins brown. Venation: R_{1+2} entire; R_2 about one-half the last section of R_1; cell 1st M_2 small; m-cu on M_{3+4} before fork.

Abdominal tergites obscure yellow; a conspicuous median black vitta that is narrowly broken at caudal border of segments; sublateral stripes poorly indicated; sternites beyond midlength of second light gray pruinose. Ovipositor (Plate 3, fig. 38) very short and obtuse, at first sight closely simulating the hypopy-

gium of a male; cerci, *c*, short and blunt, as in group. Immediately ventrad of the cerci protrudes a median, depressed, tongue-shaped lobe that is densely clothed with setulæ. A pair of compressed yellow blades, obliquely truncated and coarsely toothed at tips, lie at the outer angles of the ventral region of the genital chamber.

Habitat.—Eastern Siberia (Kamchatka).

Holotype, female, Kamchatka River, 159° east longitude, 56° north latitude, August 11, 1914 (*Bjeloussov*), No. 556. (Hydrographic Expedition to the Pacific.)

In the females of the *fascipennis* (*bicornis*) group, the ovipositor is greatly reduced and but feebly sclerotized, the cerci being blunt and obtusely triangular in outline. The present fly shows this condition unusually developed, the ovipositor thus being of an unusually primitive type. No near ally is known to me, unless, perhaps, it is *Tipula* (*Lunatipula*) *turanensis* sp. nov., which is most readily told by the yellowish ground color of the thorax and the very small cell 1st M_2 of the wings.

TIPULA (LUNATIPULA) TURANENSIS sp. nov. Plate 1, fig. 12; Plate 3, figs. 39–41.

Belongs to the *fascipennis* group; general coloration yellow, the præscutum with three darker stripes that are sometimes poorly indicated; antennæ (male) moderately long, if bent backward extending about to base of abdomen; wings pale grayish yellow, the prearcular and costal regions pale yellow; cell 1st M_2 small, pentagonal; male hypopygium with the ninth tergite bearing conspicuous ventral spines; eighth sternite with lateral tubercles that are tipped with elongate spinous setæ.

Male.—Length, about 12 to 14 millimeters; wing, 13 to 15; antenna, about 4 to 4.5.

Female.—Length, about 13 millimeters; wing, 14.

Male.—Frontal prolongation of head brownish yellow, a little darker laterally beneath; nasus distinct; palpi light brown, the terminal segment dark brown. Antennæ (male) relatively long, if bent backward extending about to the base of abdomen; scape and pedicel yellow; flagellar segments beyond the first almost uniformly brownish black, the basal enlargements a trifle darker; all verticils basal in position, subequal to the segments. Head yellowish brown.

Mesonotal præscutum brownish yellow, with three dark stripes that are dull brownish and, in cases, ill-delimited, the median stripe more or less divided by a capillary pale line; scutal lobes similarly variegated with brown; remainder of notum obscure brownish yellow. Pleura chiefly pale, the sternopleurite and

anepisternum somewhat darker. Halteres pale, the central ring of each knob more darkened. Legs with the coxæ and trochanters obscure yellow; femora yellow, the tips weakly darkened; tibiæ and tarsi obscure yellow, the outer tarsal segments a little darker. Wings (Plate 1, fig. 12) pale grayish yellow, the prearcular and costal regions, together with a line between branches of Cu, clear light yellow; stigma bicolorous, the proximal half yellow, the distal half pale brown, the division between the two oblique; obliterative area along cord not unusually wide or conspicuous but involving an unusual number of veins, including all those inclosing cell 1st M_2 with the exception of M_{3+4}, in addition to the anterior cord, outer end of Rs, and the extreme bases of R_{2+3}, R_{4+5}, and outer section of M_{1+2}; veins brown, yellow in the luteous areas. Macrotrichia of veins beyond cord abundant; squama with long conspicuous setæ. Venation: Cell R_2 deep; cell 1st M_2 small, pentagonal; m-cu at or very close to fork of M_{3+4}.

Abdominal tergites brownish yellow, the median line infuscated; sternites more uniformly pale. Male hypopygium (Plate 3, fig. 39) with the tergite, 9*t*, entirely separated from the sternite, 9*s*; basistyle, *b*, separated from sternite only by a broadly membranous ventral incision. Ninth tergite (Plate 3, fig. 40, 9*t*) pale, longer than broad, gently widened outwardly, the caudal margin with a V-shaped notch that is further produced at base into a small rounded incision; lobes of tergite acute or nearly so; ventral-lateral angles of tergite produced caudad into conspicuous sclerotized horns, the blunt tips slightly upcurved. Ninth sternite broadly incised and membranous medially, with two curved hornlike spines in the membrane; dorsocaudal angle of sternite with a stout fingerlike lobe that is tufted with abundant long pale setæ. Dististyle (Plate 3, fig. 40, *d*) single, with a broad flattened blade at posterior angle that is probably the homologue of the outer dististyle. Eighth sternite (Plate 3, fig. 41, 8*s*) broad and moderately sheathing, each lateral angle produced into a slender fingerlike lobe that is tipped with a long bristle, this being approximately twice as long as the tubercle itself; besides this spine each tubercle bears additional long pale setæ; median area of sternite between tubercles transverse, fringed with pale setæ that are shorter near the midline, forming two dense groups at this place. The lateral lobes and median fringe are loosely connected by membrane with the actual body of the sternite.

Female.—Characters as in the male, differing in the sexual features. Antennæ much shorter and more nearly unicolorous yellow. Ovipositor with cerci small, roughly triangular in outline; hypovalvæ compressed. Between the valves an acute spine that is directed outwardly.

Habitat.—Eastern Siberia (Amur, Baikal).

Holotype, male, Turan, Baikal; in my collection through purchase from Staudinger-Bang Haas. Allotype, female, Seja River, Amur Province, June 27 to 29 (*Rittig*), No. 640. Paratype, male, Samnjur River, Habarovsk district, Amur, 135° east longitude, 48° 30′ north latitude, July 7 to 11, 1910 (*Stackelberg*).

The unusually small cell 1st M_2 would indicate that this species is highly specialized in the *fascipennis* (*bicornis*) group. It may be readily told from all other regional members, excepting *pseudogyne* sp. nov., by the small size. The yellowish ground color of the thorax and the details of venation, especially the shape of cell 1st M_2, readily separate the present species from *pseudogyne*.

TIPULA MITOPHORA sp. nov. Plate 1, fig. 13; Plate 4, figs. 42, 43.

General coloration gray; præscutum yellowish gray, with four narrow brown stripes; antennæ (male) very long, approximately three-fourths the length of the body; wings tinged with brownish, with a very vague darker and paler pattern that is so diffuse as to give the wing an almost unicolorous appearance; R_2 long, erect; R_{1+2} atrophied beyond the basal spur; male hypopygium with the ninth tergite pale, notched medially.

Male.—Length, 12 to 13 millimeters; wing, 15 to 16; antenna, 9 to 10.

Frontal prolongation of head yellow; nasus distinct; palpi brownish black. Antennæ (male) of unusual length, approximately three-fourths or more of the entire body; basal three segments yellow, succeeding segments bicolorous, the basal enlargements black, the remainder brownish yellow; outer segments passing into brownish black; flagellar segments elongate; verticils much shorter than the segments, those at near midlength of the segments longer than the basal ones; terminal segment reduced to a tiny thimble-shaped structure. Head gray.

Mesonotal præscutum yellowish gray with four narrow brown stripes; intermediate pair widely separated by a line of the ground color, their mesal edges very narrowly and indistinctly bordered by blackish; scutum yellowish gray, the lobes variegated by two confluent brown areas; scutellum dark gray, with

a vague blackish median vitta; mediotergite light gray. Pleura gray, the propleura, anepisternum, and sternopleurite clearer gray, the posterior sclerites a little more whitish gray. Halteres pale yellow, the knobs weakly darkened. Legs with the coxæ light gray; trochanters pale yellow; femora obscure yellow, the tips blackened, somewhat more extensively so on forelegs; tibiæ light brown; tarsi black; tibial spur formula 1–2–2; claws small, simple. Wings (Plate 1, fig. 13) tinged with brownish; stigma darker brown; vague brown seams along vein Cu and on anterior cord; a very vague whitish area near outer end of cell M; obliterative area before stigma small and ill-defined; that area across cell 1st M_2 clearly defined. Macrotrichia of veins small but abundant, on all veins beyond cord, including R_2, but excluding m and basal section of M_3. Venation: Tip of R_{1+2} atrophied, only a tiny basal spur being preserved; R_2 unusually long so that R_1 and spur of R_{1+2} are almost in longitudinal alignment; m longer than petiole of cell M_1; m-cu on M_4 some distance beyond origin; cell 2d A of moderate width.

Abdominal tergites orange-yellow to yellow, narrowly trivittate with black, the sublateral stripes very narrow and indistinct on basal half of organ; median stripe continuous and very conspicuous; fifth and succeeding segments more uniformly blackened; basal sternites more uniformly yellowish. Male hypopygium (Plate 4, fig. 42) with the tergite, 9*t*, and basistyle, *b*, entirely distinct from the sternite, 9*s*. Ninth tergite (Plate 4, fig. 43, 9*t*) entirely pale; caudal margin with a V-shaped notch, the base of which is further incised by a smaller quadrate opening; lobes thus formed sublateral in position, obliquely truncated to subacute. Outer dististyle relatively long and slender. Inner dististyle, *id*, with two blackened, beaklike points. Basistyle, *b*, with a group of scattered yellow setæ at ventromesal angle. Ninth sternite rather shallow, incised medially. Eighth sternite unarmed, not projecting.

Habitat.—Eastern Siberia (Amur, Ussuri).

Holotype, male, Cape Dshaore, mouth of Amur River, June 19, 1910 (*Derbeck*), No. 307. Paratopotypes, 5 males, June 17 to 19, 1910, Nos. 306, 308 to 311. Paratype, male, Nikolajevsk, Naleo River, Ussuri, 143° 30′ east longitude, 53° 30′ north latitude, May 1 to 14, 1908 (*Soldatov*), No. 659.

The unusually elongate antennæ of the male sex, together with the atrophied R_{1+2}, mark the present insect as being very distinct from all other regional species. By keys to the European

members of the genus, the fly runs to *hortulana* Meigen, an entirely different fly with a distinct wing pattern, short male antennæ, and with the radial venation quite unlike that of the present species.

TIPULA APICISPINA sp. nov. Plate 1, fig. 14; Plate 4, fig. 44.

General coloration of head and thorax light ashy gray, the four præscutal stripes a very little darker gray; antennal flagellum black; halteres yellow, the knobs dark brown; legs black, the femoral bases very narrowly yellow; wings pale brown, the prearcular and costal regions strongly yellow, the disk conspicuously variegated with whitish, including a complete transverse fascia beyond cord; R_{1+2} entire; basal segments of abdomen yellow, the outer segments blackened; male hypopygium with the inner dististyle having the outer basal angle produced ventrad into a conspicuous black spine.

Male.—Length, about 14 millimeters; wing, 15.5; antenna, about 4.

Frontal prolongation of head light brown; nasus distinct; palpi black. Antennæ moderately long, if bent backward extending about to the root of halter; scape and pedicel light yellow; flagellum black, the proximal end of the basal segment a little brightened; basal enlargements of flagellar segments small, the longest verticils subequal to the segments; terminal segment small, thimblelike. Head gray, with a narrow brown median vitta; vertical tubercle distinct.

Mesonotal præscutum light ashy gray, with four scarcely evident darker gray stripes; setæ of interspaces very small, pale; scutum ashy gray, the centers of the lobes vaguely darker gray; scutellum testaceous-brown; mediotergite light gray. Pleura gray, the mesepisternum clearer gray than the posterior sclerites; sternopleurite glabrous. Halteres pale yellow, the knobs dark brown. Legs with the fore and middle coxæ light gray pruinose; posterior coxæ yellow; trochanters yellow; remainder of legs black, the femoral bases very narrowly yellow. Wings (Plate 1, fig. 14) with the ground color pale brown, the prearcular and costal regions strongly yellow; stigma darker brown; disk of wing variegated by whitish, including a complete crossband beyond cord; other conspicuous white areas before cord in cell R_1 and outer end of cell R, near outer end of cell M, base of cell M, most of Cu, and before midlength of 1st A; veins brown. Macrotrichia on most longitudinal veins beyond level

of cord; on R_{1+2} only on basal half; lacking on all but last section of vein M_{1+2} and on basal section of M_3; squama naked. Venation; R_{1+2} entire; m subequal to petiole of cell M_1; M_{3+4} subequal to m.

Basal segments of abdomen yellow, the tergites with a narrow darkened median line; fourth and succeeding segments blackened. Male hypopygium (Plate 4, fig. 44) with the tergite, 9*t*, entirely separate from the sternite, 9*s*; basistyle relatively large, cut off from sternite only by a dorsal suture that is more than one-half complete. Ninth tergite, 9*t*, quadrate, the caudal margin nearly transverse, with a small U-shaped median notch that bears a small acute spine at base; dorsal surface of tergite with a median depressed groove back from the spine, this area devoid of trichia. Outer dististyle relatively narrow at base, more expanded at near one-fourth the length, conspicuously setiferous. Inner dististyle, *id*, bidentate at apex, the outer basal angle produced into a long straight spine that is directed ventrad when the style is in a position of rest; outer margin of style below midlength with two, blackened, coarsely toothed plates. Gonapophyses, *g*, blackened, at tips with two unequal black spines that extend in a straight line. Ædeagus stout.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Sedanka, Vladivostok, July, 1913 (*Sycheff*), No. 700. Paratype, a fragmentary specimen, Tigrovaja, Suchan district, August 5, 1927 (*Stackelberg*), No. 61.

Tipula apicispina is most nearly allied to *T. matsumuriana* Alexander (Japan), differing conspicuously in the peculiar structure of the inner dististyle of the male hypopygium, as well as in colorational details, notably the almost unicolorous light gray præscutum and the almost completely blackened femora.

TIPULA MUPINENSIS sp. nov. Plate 1, fig. 15; Plate 4, fig. 45.

General coloration gray, the præscutum with four darker gray stripes, the intermediate pair narrowly margined by dark brown to appear trivittate; antennal scape and pedicel light yellow; femora yellow, the tips not darkened; wings with the ground color brown, variegated by whitish areas, including a narrow, nearly complete fascia beyond cord; R_{1+2} entire; Rs nearly twice as long as m-cu; basal abdominal segments orange-yellow, the outer segments darkened; male hypopygium with the eighth sternite produced medially and densely fringed with yellow setæ.

Male.—Length, about 14 millimeters; wing, 15.5.

Frontal prolongation of head yellowish gray above, darker laterally; nasus lacking or virtually so; basal two segments of

palpi brown, the outer segments black. Antennæ of moderate length, if bent backward extending about to wing root; scape and pedicel yellow; flagellum brownish black, the ends of the basal segment paler; longest verticils subequal to the segments. Head brownish gray.

Mesonotal præscutum light gray, with four darker gray stripes, the intermediate pair of which are narrowly bordered by brown, their margins presenting a brown trilineate appearance on the interspaces; posterior sclerites of notum dark gray. Pleura gray, indistinctly variegated with darker gray. Halteres pale yellow, the knobs dark brown. Legs with the coxæ gray; trochanters yellow; femora yellow, the tips not darkened; tibiæ brownish yellow; tarsi passing into brown; tibial spur formula 1–2–2. Wings (Plate 1, fig. 15) with the ground color brown, the prearcular and costal regions strongly yellow; stigma and a confluent cloud on anterior cord darker brown; disk with conspicuous white areas, including a narrow, nearly complete crossband beyond cord, extending from costa nearly to midlength of cell M_3; a broader band before cord, extending from before stigma to vein Cu; a whitish spot in base of cell M; cell Cu chiefly pale, the extreme base and a spot at near midlength remaining of the ground color; anal cells of the ground color; cell 1st A variegated by whitish near base and at margin close to vein 2d A; veins brown, more yellowish in the flavous areas. Venation: R_{1+2} entire, the distal two-thirds without trichia; m and petiole of cell M_1 nearly equal; m-cu on M_4 shortly beyond origin; Rs a little less than twice m-cu.

Basal abdominal segments orange-yellow, the outer segments blackened. Male hypopygium (Plate 4, fig. 45) with the tergite, 9*t*, and basistyle, *b*, entirely distinct from the sternite, 9*s*. Ninth tergite, 9*t*, extensive, the posterior half more narrowed; caudal margin subtruncate to very feebly emarginate, the central portion blackened and produced into a minute median black tooth. Outer dististyle very narrow at base, gradually widened to a triangularly flattened blade. Inner dististyle, *id*, with the outer portion bearing a conspicuous spinous lobe. Membrane of ninth sternite with a group of about a dozen elongate setæ. Gonapophyses, *g*, bispinous. Eighth sternite, 8*s*, produced medially into an entire lobe, the caudal margin densely fringed with long yellow setæ, many of which are borne on dorsal surface of sternal plate, remote from margin.

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet (*Graham*).

The nearest regional allies of the present fly are *Tipula pedicellaris* Alexander and *T. vivax* Alexander, both from the high mountains of the China-Tibet border. The former has the antennal scape darkened and the femora chiefly black; the latter has the pattern of the præscutum differently arranged and the tips of the femora narrowly and very abruptly blackened.

TIPULA MACROLABIS Loew.

Tipula macrolabis LOEW, Berlin. Ent. Zeitschr. 8 (1864) 58.

This is a common and very widely distributed crane fly in Boreal North America, being known from the Hudsonian and lower Arctic-Alpine zones of Canada from Labrador to Alaska, following southward along the Rocky Mountains to New Mexico (altitude 8,000 to 11,000 feet). Herewith recorded for the first time from the Palæarctic Region.

Kamchatka, Petropavlovsk, 1898 (*Gondatti*). Russian Academy of Sciences No. 588.

TIPULA FORTISTYLA sp. nov. Plate 1, fig. 16; Plate 4, fig. 46.

Belongs to the *flavolineata* group, allied to *curvicauda;* general coloration gray pruinose, the median præscutal stripe polished black; antennæ (male) about one-half the length of body, the basal five segments light yellow, the succeeding segments light brown; femora and tibiæ yellow, the tips narrowly darkened; wings brownish yellow, the prearcular and costal regions bright yellow; stigma brown, its proximal end yellow; male hypopygium with the outer dististyle unusually powerful in structure, strongly curved, its apex weakly notched.

Male.—Length, about 17 millimeters; wing, 19; antenna, about 8.

Frontal prolongation of head light brown; palpi pale yellowish brown to yellow, the apex of basal segment a little darker. Antennæ (male) relatively long, nearly one-half the length of body; basal five segments light yellow, the succeeding segments passing into light brown; flagellar segments elongate, with strong verticils at near midlength, in addition to the basal set, all verticils much shorter than the segments. Head gray, more yellowish on front.

Pronotum gray, more infuscated medially. Mesonotal præscutum with the ground color brownish yellow, pruinose, with three dark stripes, the broad median one black, highly polished, the lateral stripes obscured by pruinosity; posterior sclerites of mesonotum black, heavily gray pruinose. Pleura with anepisternum and sternopleurite light blue-gray, the posterior sclerites

much paler, more whitish; dorsopleural membrane pale yellow. Halteres with slender stems and small knobs, pale yellow, the knobs infuscated. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips very narrowly but conspicuously brownish black; tibiæ yellow, the tips very narrowly darkened; tarsi black, the basitarsi darker at proximal ends; claws (male) with a small basal spine. Wings (Plate 1, fig. 16) tinged with brownish yellow, the costal and prearcular regions bright yellow; stigma brown, its proximal end light yellow; a poorly defined brown cloud on anterior cord; obliterative areas restricted, lying before stigma and across base of cell 1st M_2, interrupted at junction of r-m with R_5; veins brown, brighter in the yellow areas. Venation: R_{1+2} and R_3 divergent; fork of M_{3+4} lying proximad of r-m; cell 2d A narrow.

Abdominal tergites yellow, becoming more obscure and slightly pruinose beyond basal third of organ; outer segments more infuscated; intermediate tergites with caudal and sublateral portions slightly darkened, the lateral borders pale; second tergite with a brown ring beyond midlength; sternites more infuscated, brighter caudally and laterally; hypopygium brownish black. Male hypopygium (Plate 4, fig. 46) with the tergite entirely separate from the sternite; basistyle, *b*, very large, chiefly fused with sternite, indicated by a ventral suture. Ninth tergite, 9*t*, with the lateral lobes obtuse; submedian teeth slender, directed slightly toward one another, separated only by a narrow notch. Outer dististyle, *od*, constructed much as in *curvicauda* but shorter and stouter, more strongly curved; at apex with a weak notch that is densely set with erect pale setulæ. Inner dististyle, *id*, as shown. Ninth sternite tumid, the two sides separated by a narrow V-shaped notch, each half with abundant erect setulæ. Eighth sternite unarmed.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Vladivostok, June 27, 1907 (*Smirnov*), No. 651.

The present fly belongs to the *flavolineata* group, being closest to *Tipula curvicauda* and *T. issikii*, from both of which it is readily told by the shorter antennæ of the male, with the basal flagellar segments extensively pale, and by the structure of the male hypopygium, especially the very short and stout, strongly curved, outer dististyle.

The *flavolineata* group includes, besides *flavolineata* Meigen (Europe), four Japanese species (*curvicauda* Alexander, *dichroistigma* Alexander, *issikii* Alexander, and *nigrosignata* Alex-

ander), together with the present fly. The various members of the group agree in the unusually elongate antennæ of the male and in the general structure of the ninth tergite of the male hypopygium, the caudal margin of which is emarginate and provided with two small submedian blackened teeth at base of notch. *Tipula flavolineata* and *T. dichroistigma* have the præscutum pruinose, but the other species have it more or less polished black, sometimes very conspicuously so. *Tipula flavolineata, T. dichroistigma,* and *T. nigrosignata* have the outer dististyle small and relatively insignificant, but still more or less arcuate and differing in conformation from the organ in the other members of the genus; *T. curvicauda, T. issikii,* and *T. fortistyla* have the outer dististyle very large and powerfully constructed.

Edwards [2] did not assign *flavolineata* to any of the subgenera that he defined, and I hesitate to attempt such an assignment at this time, though with more numerous species before me. All species have the nasus elongate; R_{1+2} entire; fork of M_{3+4} unusually close to the base of cell 1st M_2, as in the *tricolor* group of the subgenus *Tipula,* lying slightly proximad of r-m; macrotrichia of veins beyond cord small and relatively sparse; squama naked. Tibial spur formula 1–2–2. Male hypopygium with the tergite entirely separate from the sternite; basistyle large, cut off only by a ventral suture.

The somewhat similar but not closely allied *juncea* (*pribilofensis*) group is likewise eminently characteristic of the boreal portions of the Holarctic region. Its affinities seem to lie closer to *Vestiplex,* but it seems highly probable that a new subgeneric group will be required for the reception of the included species.

LIMONIINÆ

PEDICIINI

PEDICIA (TRICYPHONA) USSURICA sp. nov. Plate 1, fig. 17; Plate 4, fig. 47.

Allied to *unicolor;* general coloration gray, the præscutum with four conspicuous blackish stripes; antennæ black throughout, 14- or 15-segmented, the flagellar segments short and crowded; halteres uniformly pale yellow; femora obscure yellow basally, the tips brownish black, broadest on forelegs; wings pale yellow, the prearcular region clear light yellow; pale brown seams along cord; venation very variable, r-m connecting at or beyond fork of Rs; cell 1st M_2 elongate, closed; male hypopygium with the lateral angles of tergite produced into short glabrous arms; interbase weakly notched at apex.

[2] Ann. & Mag. Nat. Hist. X 8 (1931) 82.

Male.—Length, about 7.5 to 8 millimeters; wing, 7.5 to 8.

Female.—Length, about 8 to 9 millimeters; wing, 8 to 8.5.

Rostrum and palpi black. Antennæ short, black throughout; segments varying in number from fourteen to fifteen, the outer ones very short and crowded. Head dark gray; vertical tubercle small.

Pronotum dark gray. Mesonotal præscutum light gray, with four conspicuous blackish stripes, the intermediate pair nearly confluent at anterior ends; scutum gray, each lobe variegated by two blackish areas; posterior sclerites of mesonotum dark gray. Pleura dark gray; dorsopleural membrane brown. Halteres uniformly pale yellow. Legs with the coxæ dark gray; trochanters yellow; femora obscure yellow basally, the tips brownish black, broadest on the forelegs where about two-thirds to three-fourths is included, very narrow on the middle and posterior legs where only the distal fourth or fifth is darkened; tibiæ dark brown, the posterior tibiæ much brighter, narrowly tipped with dark brown; tarsi black. Wings (Plate 1, fig. 17) with the ground color pale yellow, the prearcular region clear light yellow; narrow but conspicuous pale brown seams on anterior and posterior cords, narrowly interrupted at the fork of M; stigma very pale to lacking; veins brown, light yellow in the prearcular region. Venation: Sc_2 before origin of Rs a distance about equal to one-third to one-half the length of Rs, the latter somewhat variable in length, angulated at origin; petiole of cell R_4 variable, in cases exceeding r-m, in other instances shorter than this element; r-m connecting with R_{4+5} before midlength, sometimes as far proximad as the end of Rs; cell 1st M_2 elongate; m variable in position, from opposite the fork of M_{1+2} to some distance before this fork, in the latter case (as figured) m being shorter than the petiole of cell 1st M_2; m-cu likewise variable in position, from being placed at the fork of M_{3+4} to some distance before this fork, in cases before midlength of M_{3+4}.

Abdominal tergites dark brown, the caudal margins of the intermediate segments very narrowly yellow; basal sternite dark, the intermediate ones pale brown, the outer segments again darkened. In female, abdomen more uniformly dark brownish gray; ovipositor large, powerfully constructed, horn yellow. Male hypopygium (Plate 4, fig. 47) with the tergite, 9*t*, broad, the caudal margin very shallowly emarginate, the lateral angles produced caudad and laterad into short glabrous horns; median region of tergite densely setiferous. Basistyle, *b*, divided at apex into two lobes, the broader one densely set with very nu-

merous small blackened pegs that present an unusually uniform arrangement; inner lobe of basistyle very small, slender, pale, with coarse setæ. A single dististyle, *d*, which is subequal in length and size to the inner apical lobe of basistyle; lower margin at base fringed with about six elongate setæ, with smaller setæ near apex. Interbase, *i*, a powerful curved rod, light yellow, the apex shallowly and unequally bidentate, the surface near base with numerous fine setæ.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Maiche region, near Shkotovo, June 5, 1927 (*Martynov*), No. 208. Allotype, female, Tigrovaja, Suchan district, June 16, 1927 (*Stackelberg*), No. 34. Paratopotypes, one of each sex, with type, Nos. 204, 209.

The present fly is most nearly related to Japanese species such as the much larger *Pedicia* (*Tricyphona*) *optabilis* (Alexander), differing most evidently in the wing pattern and details of structure of the male hypopygium. Among the European species, it is more distantly allied to species such as *P.* (*T.*) *schummeli* (Edwards) and *P.* (*T.*) *unicolor* (Schummel), differing from both in the diagnostic features listed, the most evident being the closed cell 1st M_2 and the pale brown but distinct clouding along cord of wing.

HEXATOMINI

LIMNOPHILA (LIMNOPHILA) SOLDATOVI sp. nov. Plate 1, fig. 18.

General coloration light gray, the præscutum with scarcely indicated darker gray stripes; halteres uniformly pale yellow; legs yellow, the tips of femora narrowly blackened, the amount subequal on all legs; wings with the ground color whitish, heavily patterned with dark brown, including four broken fasciæ and scattered smaller dots in interspaces; m-cu at near midlength of cell 1st M_2.

Female.—Length, 15 to 17 millimeters; wing, 10.5 to 11.5.

Rostrum gray; palpi brownish black. Antennæ with the scape and pedicel black, heavily dusted with gray; flagellum pale yellowish brown, the outer segments darker; basal segments large, the outer segments more slender, with long conspicuous verticils. Head clear light gray, prolonged behind.

Pronotum massive, light gray. Mesonotal præscutum clear gray with four scarcely evident darker gray stripes, the extreme cephalic portions of the intermediate pair blackened, appearing as if the pruinosity were denuded, but the appearance is quite the same in all specimens of the series; pseudosutural foveæ

black, triangular, large and conspicuous; tuberculate pits lacking; posterior sclerites of notum clear light gray, the centers of the scutal lobes very vaguely darkened. Pleura gray, the dorsopleural region light brown. Halteres uniformly pale yellow. Legs with the coxæ light gray; trochanters yellow; femora yellow, the tips narrowly blackened, the amount subequal on all legs and including about the outer sixth or less; tibiæ obscure yellow, the bases narrowly, the tips a little more broadly, blackened; tarsi black; legs conspicuously hairy. Wings (Plate 1, fig. 18) with the ground color whitish, with a heavy brown pattern arranged as four more or less broken crossbands, with scattered smaller brown dots in the interspaces; basal fascia postarcular, extending from C to Cu; second band at level of origin of Rs, broadly broken at cell M; third fascia at cord, forking at costa and inclosing a small yellow area beyond Sc_2; last band including the narrow wing apex, in cases extending from tips of veins R_3 to M_4, in other instances the two latter areas separate from the main apical mass; dots in interspaces sparse, lacking in the basal radial field, elsewhere more or less restricted to the vicinity of the veins; veins brown, more yellowish in the interspaces. Macrotrichia of veins relatively sparse, lacking on R_{2+3+4}, R_{2+3}, R_3, or R_4; a scattered series on distal section of R_5, more crowded at outer end; outer medial branches with sparse scattered trichia. Venation: R_{2+3+4} short to very short; fork of cell M_1 short; m-cu at or close to midlength of cell 1st M_2; anterior arculus preserved.

Abdomen clear light gray, the extreme caudal portions of the segments ringed with pale brown; narrow black transverse impressions on basal rings of segments, with more widely separated oblique dashes on posterior rings. Ovipositor dark reddish brown, the tips of cerci narrowly pale.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Osernaja, mouth of Amur River, June 12 to 25, 1910 (*Soldatov*), No. 666. Paratopotypes, 1 female, with the type; 1 female, May 31, 1910, Nos. 665, 667.

This interesting crane fly is named in honor of Mr. W. Soldatov, who has collected numerous Tipulidæ near the mouth of the Amur and on Saghalien Island. The nearest ally is *Limnophila* (*Limnophila*) *martynovi* Alexander, which agrees in the general features of structure and coloration, as the uniformly pale halteres and the reduced trichiation of the wings. Apart from the venational peculiarities of *martynovi*, as the loss of crossveins m and m-cu, features which may prove to represent

abnormalities of the unique type, the present fly differs in the pale antennal flagellum; indistinct tuberculate pits; narrowly blackened femora, with the degree of darkening nearly equal on all legs; and the more fully developed wings. These two species differ from the other regional members of the subgenus in the uniformly pale halteres.

LIMNOPHILA (LIMNOPHILA) POLITOSTRIATA sp. nov. Plate 1, fig. 19; Plate 4, fig. 48.

General coloration of thorax light gray, the præscutum more yellowish gray, with four, narrow, polished, black stripes; knobs of halteres dark brown; femora yellow, the tips narrowly blackened; tibiæ yellow, the extreme bases and tips darkened; wings whitish subhyaline, heavily patterned with brown; abdomen black, sparsely pruinose; male hypopygium with the outer angle of basistyle produced into a smooth blackened spine.

Male.—Length, about 10 millimeters; wing, 10.

Female.—Length, about 11 to 14 millimeters; wing, 9.5 to 11.

Rostrum gray; palpi black. Antennæ black throughout; in male relatively short, if bent backward ending some distance before wing root; verticils long and conspicuous. Head light gray.

Pronotum massive, light gray. Mesonotal præscutum yellowish gray with four, intense black, highly polished stripes, the intermediate pair narrowly separated by a capillary line of the ground color, not attaining the suture; lateral stripes crossing the suture and covering almost all of scutal lobes; pseudosutural foveæ conspicuous, black, triangular in outline; remainder of mesonotum light gray, the scutellum broad. Pleura light gray; dorsopleural region brown. Halteres pale yellow, the knobs infuscated. Legs with the coxæ light gray pruinose; trochanters dark brown; femora yellow, the tips narrowly blackened, the amount subequal on all legs, involving the outer sixth or seventh; tibiæ light yellow, the very narrow bases and very little wider tips blackened; tarsi light brown, the outer segments darker. Wings (Plate 1, fig. 19) whitish subhyaline, the costal region concolorous; a heavy dark brown pattern, appearing as about four or five major costal areas, marginal spots at ends of all longitudinal veins and numerous small dots in all cells, almost lacking in the radial field; the two largest costal areas, lying at origin of Rs and in stigmal region, are more or less Y-shaped, the fork inclosing a tiny pale costal spot; veins yellow, darker in the clouded areas. Macrotrichia on outer ends

of veins beyond cord, including R_4, all of R_5, and distal ends of outer medial veins; anterior branch of Rs without trichia. Venation: Rs elongate, arcuated to angulated and spurred at origin; R_{2+3+4} very short; R_{1+2} and R_2 subequal; cell M_1 shorter than its petiole; m-cu at or close to fork of M; anterior arculus preserved.

Abdomen black, the surface sparsely pruinose; hypopygium black. Male hypopygium (Plate 4, fig. 48) with the outer apical angle of basistyle, *b*, produced into a slender smooth blackened spine. Ædeagus, *a*, and gonapophyses, *g*, elongate, the latter pale in color.

Habitat.—Eastern Siberia (Ussuri, Saghalien).

Holotype, male, Osernaja, mouth of Amur River, Ussuri, June 24, 1915 (*Chernavin*), No. 716. Allotype, female, Kuegda, Saghalien Island, July 10, 1908 (*Soldatov*), No. 687. Paratopotype, female, Osernaja, June 28, 1908 (*Soldatov*), No. 671. Paratype, female, Cape Pronge, mouth of Amur River, 141° 15′ east longitude, 53° north latitude, June 24, 1910 (*Derbeck*), No. 314.

Limnophila (*Limnophila*) *politostriata* is very different from the other known members of the typical subgenus *Limnophila* (*Pœcilostola*) in the very distinct præscutal stripes and acute blackened spine of the basistyle of male hypopygium. The other generally similar regional members either have the basistyle unarmed (*japonica* Alexander, *varicornis* Coquillett) or else have the outer lobe of basistyle pale and not constructed as a glabrous spine (*pictipennis* Meigen).

HEXATOMA (ERIOCERA) ÆQUINIGRA sp. nov. Plate 1, fig. 20.

Belongs to the *spinosa* group; mesonotal præscutum yellowish gray, with four narrow dark brown stripes, the intermediate pair separated by a grayish line that is slightly wider than the stripes; setæ of thorax unusually long and pale for the female sex; knobs of halteres dark brown; femora yellow, with the distal sixth or less blackened, the amount subequal on all legs; wings brownish yellow; stigma small, dark brown; macrotrichia on veins R_{2+3}, R_3, and distal two-thirds of R_4; cell M_1 present; abdomen dark brown, the tergites margined laterally with orange.

Female.—Length, about 33 millimeters; wing, 23.

Rostrum light brown; palpi dark brown. Antennæ with the scape and pedicel dark brown above, paler beneath; flagellum broken. Head brownish gray, reddish on either side of midline of vertical tubercle; setæ long and dense.

Mesonotal præscutum yellowish gray, the lateral interspaces suffused with light brown; four narrow dark brown stripes, the intermediate pair separated by a grayish line that is a little wider than either stripe; pubescence of notum white, unusually long and dense for the female sex; scutum grayish, each lobe with a large dark area; scutellum dark, the margin fringed with long yellow setæ; mediotergite gray, darker caudally. Pleura clear light gray, the dorsopleural region variegated with dark brown and buffy; setæ of propleura long and conspicuous, pale. Halteres light yellow, knobs dark brown. Legs with the coxæ light gray, clothed with long pale setæ; trochanters yellow; femora yellow, the tips of all legs narrowly blackened, the amount subequal on all legs, including approximately the distal sixth or less; tibiæ reddish brown, the tips narrowly blackened; tarsi reddish brown, the outer segments black. Wings (Plate 1, fig. 20) tinged with brownish yellow; stigma small, dark brown; vague dusky washes along Rs, Cu, and 2d A; veins chiefly dark brown, Sc and most of M more yellowish. Macrotrichia of veins unusually abundant for a member of this group; series of trichia on entire length of R_{2+3} and R_3, and on about the distal two-thirds of outer section of R_4, the latter series including from twenty-five to thirty punctures; trichia on R_5 sparse and scattered; no trichia on outer medial veins. Venation: R_{2+3} a little shorter than R_3; Rs in alignment with R_5; m-cu before midlength of cell 1st M_2.

Abdomen dark brown, the sternites sparsely pruinose; lateral margins of tergites narrowly but conspicuously orange; tergites each with four transverse blackened impressions on basal ring. Ovipositor with the elongate valves deep cherry red.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Tigrovaja, Suchan district, August 2, 1927 (*Stackelberg*).

The nearest ally of this fly is *Hexatoma* (*Eriocera*) *stricklandi* (Edwards), of Japan, which differs in the much paler wings, three dark præscutal stripes, and unequally blackened femora, the posterior femora being much more extensively darkened than are the other two pairs. The present fly further differs from most of the other regional members of the group in the rather unusual degree of trichiation of the wing veins, there being a series on more than the distal half of vein R_4, which, in most of the other species of the *spinosa* group, is quite glabrous.

HEXATOMA (ERIOCERA) ATRIPES sp. nov. Plate 1, fig. 21.

Belongs to the *spinosa* group; general coloration brownish black; antennæ and legs black throughout; mesonotal præscutum with the lateral stripes narrow, polished; wings tinged with brown; macrotrichia on radial veins beyond cord.

Female.—Length, about 25 millimeters; wing, 18.3 by 5; antenna, 6.

Rostrum brownish black; palpi black. Antennæ 11-segmented, black throughout; flagellar segments gradually decreasing in length to end. Head broadly blackened on vertex, the lateral portions behind eyes paling to brown.

Mesonotal præscutum with the interspaces heavily pollinose with buffy; three stripes, the broad median one dull black, further divided by a deeper black median vitta that narrows to a point behind at suture; lateral stripes narrow, polished black; scutum brown, the lobes variegated by subnitidous darker brown areas; scutellum and mediotergite dark brown, very sparsely yellow pollinose. Pleura chiefly dark brown, the dorsal sternopleurite and most of pleurotergite paler. Halteres with the stem obscure yellow, the knobs blackened. Legs with the coxæ black, gray pruinose; trochanters reddish brown; remainder of legs entirely black. Wings (Plate 1, fig. 21) with a strong brown tinge, the costal region slightly darker; stigma oval, darker brown; veins dark brown. Macrotrichia on all radial veins beyond cord excepting R_{1+2} and R_2. Venation: R_{1+2} nearly three times R_2; R_{2+3+4} shorter than R_{2+3}; cell M_1 shorter than its petiole.

Abdominal tergites brownish black, the sternites a little paler; genital segment brownish gray pruinose. Cerci elongate, blackened, basally, paling to reddish at tips.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Vinogradovka, 133° 50′ east longitude, 43° 20′ north latitude, August 5, 1929 (*Djakonov*), No. 531.

Hexatoma (*Eriocera*) *atripes* is readily distinguished from all other described members of the *spinosa* group by the uniformly blackened legs.

HEXATOMA (ERIOCERA) USSURIENSIS sp. nov. Plate 1, fig. 22; Plate 4, fig. 49.

Belongs to the *verticalis* group; size large (wing, male, 15 millimeters or more); general coloration gray, the præscutum with four more-blackened stripes; antennæ (male) elongate;

vertical tubercle obscure yellow, polished black at summit; femora yellow, the tips very narrowly blackened, the amount subequal on all legs; wings with a faint brownish tinge, the oval stigma darker brown; m-cu close to fork of M.

Male.—Length, 11 to 12 millimeters; wing, 15 to 16; antenna, about 44 to 46; length of flagellar segment 1, 6 millimeters; segment 2, 7.6; segment 3, 7.5.

Female.—Length, 14 to 15 millimeters; wing, 13 to 14.5; antenna, about 3.8.

Rostrum pale brown; palpi black. Antennæ of male with the scape very large, yellow beneath, darker above; pedicel very small, brown; flagellum black; segments with conspicuous erect spines that are arranged in two rows; first flagellar segment with about twenty spines in each row, second segment with about twenty-eight, third segment with about twenty-one such spines, on outer segments becoming more scattered but fully as large and strong. Antennæ of female 11-segmented, the basal three or four segments pale, the remainder black. Head brownish gray, the conspicuous vertical tubercle yellow, its summit polished black.

Mesonotal præscutum gray, with four more-blackish stripes, the intermediate pair being widely separated by the ground color; thorax with dense erect white pubescence in male, nearly glabrous in female; posterior sclerites of notum, together with the pleura, gray. Halteres pale yellow, the knobs dark brown. Legs with coxæ darkened and sparsely pruinose, paler at tips; trochanters obscure yellow; femora yellow, the extreme tips blackened, the amount subequal on all legs; tibiæ obscure yellow, the tips narrowly dark brown, subequal in degree to the femoral darkening; basitarsi light brown, the tips and remainder of tarsi passing into dark brown. Wings (Plate 1, fig. 22) larger and broader in male, with a very faint brown tinge, the costal portion more yellowish; stigma darker brown, oval, conspicuous; cord narrowly seamed with brown, the longitudinal veins less distinctly so; veins dark brown, Sc more yellowish. Venation: R_{2+3}, R_2, and R_{1+2} all subequal; m-cu close to fork of M, in cases a trifle before or beyond this point.

Abdominal tergites dark brown, the caudal margins of segments more blackened; sternites more variegated, obscure brownish yellow basally and laterally, the caudal margins of the segments darker. Male hypopygium (Plate 4, fig. 49) with the

inner dististyle, *id*, broad. Gonapophyses, *g*, bifid, one arm spinous, the other unusually broad and flattened. Ovipositor with the genital shield and elongate valves reddish horn-color.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Bikin, River Bikin, 134° 10′ east longitude, 46° north latitude, July 10, 1927 (*Martynov*), No. 563. Allotopotype, female, No. 568. Paratopotypes, 3 of both sexes, July 8 to 12, 1927, Nos. 564, 565, 602. Paratype, female, River Zeja, near town of Blagoveshtshensk, June 3, 1927 (*Martynov*), No. 599.

Hexatoma (*Eriocera*) *ussuriensis* is most closely allied to *H.* (*E.*) *gifuensis* Alexander (Japan), from which it differs in the conspicuously larger size in both sexes, the more broadly darkened femoral tips, and slight hypopygial distinctions.

ERIOPTERINI

RHABDOMASTIX (SACANDAGA) USSURICA sp. nov. Plate 1, fig. 23.

General coloration light yellow, the præscutum with three pale brown stripes, the median one darker in front; antennæ with the scape yellow, the remaining segments black; wings pale yellow, the veins pale brown; R_{1+2} and R_3 not widely separated at margin.

Male.—Length, about 3.5 millimeters; wing, 3.8.

Rostrum yellow; palpi brown. Antennæ with the scape light yellow; pedicel and flagellum dark brown; antennæ relatively long, if bent backward ending some distance before wing root. Head light yellow.

Mesonotum yellow, the præscutum with three pale brown stripes, the median one darker in front. Pleura clear yellow. Halteres pale, the knobs weakly darkened. Legs yellow throughout. Wings (Plate 1, fig. 23) pale yellow, the costal margin a little more suffused; veins pale brown. About six macrotrichia on central half of vein R_4; a series on almost entire length of outer section of R_5; outer branches of M with macrotrichia except on basal ends; Cu and anal veins naked. Venation: Sc_1 ending at near three-fourths the length of Rs; R_3 separated from R_{1+2} along costa by a distance less than its length; outer section of M_{1+2} unusually flaring as it leaves cell 1st M_2; m-cu beyond midlength of lower face of cell 1st M_2; basal section of M_{3+4} short to very short; cell 2d A relatively narrow.

Abdomen obscure yellow, the hypopygium clearer yellow.

Habitat.—Eastern Siberia (Ussuri).

Holotype, male, Tigrovaja, Suchan district, August 4, 1927 (*Stackelberg*), No. 24.

Rhabdomastix (*Sacandaga*) *ussurica* is very different from the only other member of the genus so far recorded from eastern Siberia, *R.* (*S.*) *usuriensis* Alexander,[3] which is black, with strongly infumed wings and with bright yellow knobs to the halteres. Other Holartic species that are generally similar in coloration to the present fly—such as *R.* (*S.*) *læta* (Loew), of Europe; *R.* (*S.*) *japonica* Alexander, of Japan; and *R.* (*S.*) *flava* Alexander, of North America—are all readily told by the much larger size. The present fly is one of the smallest species of the genus so far made known.

ORMOSIA CHANKANA sp. nov. Plate 1, fig. 24; Plate 4, fig. 50.

Belongs to the *bivittata* group; general coloration brown, the præscutum with two dark brown submedian stripes that cross the suture onto the scutal lobes; antennæ short in both sexes, black throughout; knobs of halteres dark brown; wings with a strong brown tinge, with a small, slightly darker cloud on anterior cord; male hypopygium with both dististyles elongate, the inner one subacute at tip.

Male.—Length, about 4 millimeters; wing, 4.8.

Female.—Length, about 5 millimeters; wing, 5.8.

Rostrum and palpi dark brown. Antennæ brownish black throughout, short in both sexes but a little longer in male; flagellar segments oval. Head dark brown.

Mesonotal præscutum light brown with two dark brown submedian stripes that are only narrowly separated by a ground vitta, a little divergent behind and crossing the suture onto the mesal edge of the scutal lobes; lateral stripes of præscutum represented only by dusky suffusions near suture; pseudosutural fovæ and tuberculate pits black, conspicuous; setæ of interspaces black, erect; scutum with median area broadly light brownish testaceous; scutellum pale, with a small brown median spot; mediotergite brownish gray. Pleura chiefly brown, more yellowish on posterior portion. Halteres pale, the knobs dark brown. Legs with the coxæ pale grayish brown; trochanters yellow; remainder of legs light brown or brownish yellow, the femoral tips weakly darkened; outer tarsal segments brown; in the male the legs are somewhat darker brown. Wings (Plate 1, fig. 24) with a strong brown tinge; stigma lacking; a slightly darker

[3] Proc. U. S. Nat. Mus. 68, art. 4 (1925) 13.

brown cloud on anterior cord; veins and macrotrichia darker brown. Venation: Sc_1 ending beyond fork of R_{2+3+4}, Sc_2 shortly before midlength of Rs; cell 1st M_2 small, widened outwardly, the second section of M^{1+2} from about two-fifths to one-third the last section; m-cu at fork of M.

Abdomen dark brown. Male hypopygium (Plate 4, fig. 50) with the basistyle, *b*, relatively long. Both dististyles long and slender, the outer, *od*, microscopically roughened at apex and along outer margin almost to base; inner dististyle, *id*, pale, narrowed to the subacute tip, the outer margin with a pale bituberculate flange.

Habitat.—Eastern Siberia (Ussuri).

Holotype, female, Kamen-Rybolov, Lake Chanka, 132° east longitude, 44° 15′ north latitude, July 8, 1927 (*Stackelberg*). Allotopotype, a damaged male.

The only closely allied species known to me are the western Palæarctic *Ormosia bivittata* (Loew) and the Nearctic *O. hubbelli* Alexander. The type of hypopygium, which is very distinct from all other *Ormosia* species known to me in the elongate dististyles and lack of a modified tergal plate, is very similar in all three species, even to the bituberculate flange on the inner dististyle. The subacute inner dististyle, armature of the outer dististylé, and the details of venation of the present fly are sufficiently distinct. I have selected the well-preserved female specimen as type in preference to the badly damaged male.

ILLUSTRATIONS

[*a*, Ædeagus; *b*, basistyle; *c*, cercus; *d*, dististyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternites; *t*, tergites.]

PLATE 1

FIG. 1. *Tipula* (*Tipula*) *stackelbergi* sp. nov., venation.
2. *Tipula* (*Tipula*) *subsulphurea* sp. nov., venation.
3. *Tipula* (*Tipula*) *morigera* sp. nov., venation.
4. *Tipula* (*Tipula*) *protrusa* sp. nov., venation.
5. *Tipula* (*Vestiplex*) *tumulta* sp. nov., venation.
6. *Tipula* (*Vestiplex*) *jakut* sp. nov., venation.
7. *Tipula* (*Acutipula*) *omeiensis* sp. nov., venation.
8. *Tipula* (*Acutipula*) *vana* sp. nov., venation.
9. *Tipula* (*Acutipula*) *acanthophora* sp. nov., venation.
10. *Tipula* (*Lunatipula*) *validicornis* sp. nov., venation.
11. *Tipula* (*Lunatipula*) *pseudogyne* sp. nov., venation.
12. *Tipula* (*Lunatipula*) *turanensis* sp. nov., venation.
13. *Tipula mitophora* sp. nov., venation.
14. *Tipula apicispina* sp. nov., venation.
15. *Tipula mupinensis* sp. nov., venation.
16. *Tipula fortistyla* sp. nov., venation.
17. *Pedicia* (*Tricyphona*) *ussurica* sp. nov., venation.
18. *Limnophila* (*Limnophila*) *soldatovi* sp. nov., venation.
19. *Limnophila* (*Limnophila*) *politostriata* sp. nov., venation.
20. *Hexatoma* (*Eriocera*) *æquinigra* sp. nov., venation.
21. *Hexatoma* (*Eriocera*) *atripes* sp. nov., venation.
22. *Hexatoma* (*Eriocera*) *ussuriensis* sp. nov., venation.
23. *Rhabdomastix* (*Sacandaga*) *ussurica* sp. nov., venation.
24. *Ormosia chankana* sp. nov., venation.

PLATE 2

FIG. 25. *Tipula* (*Tipula*) *stackelbergi* sp. nov., male hypopygium, details.
26. *Tipula* (*Tipula*) *subsulphurea* sp. nov., male hypopygium, details.
27. *Tipula* (*Tipula*) *morigera* sp. nov., male hypopygium, details.
28. *Tipula* (*Tipula*) *parvincisa* sp. nov., male hypopygium, details.
29. *Tipula* (*Tipula*) *protrusa* sp. nov., male hypopygium, details.
30. *Tipula* (*Vestiplex*) *tumulta* sp. nov., male hypopygium, details.
31. *Tipula* (*Acutipula*) *omeiensis* sp. nov., male hypopygium, details.
32. *Tipula* (*Acutipula*) *vana* sp. nov., male hypopygium, details.

PLATE 3

FIG. 33. *Tipula* (*Acutipula*) *cockerelliana* Alexander, male hypopygium, details.
34. *Tipula* (*Acutipula*) *acanthophora* sp. nov., male hypopygium, details.
35. *Tipula* (*Lunatipula*) *validicornis* sp. nov., male hypopygium, lateral aspect.
36. *Tipula* (*Lunatipula*) *validicornis* sp. nov., male hypopygium, details.
37. *Tipula* (*Lunatipula*) *validicornis* sp. nov., ovipositor, details.
38. *Tipula* (*Lunatipula*) *pseudogyne* sp. nov., ovipositor, details.
39. *Tipula* (*Lunatipula*) *turanensis* sp. nov., male hypopygium, lateral aspect.
40. *Tipula* (*Lunatipula*) *turanensis* sp. nov., male hypopygium, details.
41. *Tipula* (*Lunatipula*) *turanensis* sp. nov., male hypopygium, details.

PLATE 4

FIG. 42. *Tipula mitophora* sp. nov., male hypopygium, lateral aspect.
43. *Tipula mitophora* sp. nov., male hypopygium, ninth tergite.
44. *Tipula apicispina* sp. nov., male hypopygium, details.
45. *Tipula mupinensis* sp. nov., male hypopygium, details.
46. *Tipula fortistyla* sp. nov., male hypopygium, details.
47. *Pedicia* (*Tricyphona*) *ussurica* sp. nov., male hypopygium.
48. *Limnophila* (*Limnophila*) *politostriata* sp. nov., male hypopygium.
49. *Hexatoma* (*Eriocera*) *ussuriensis* sp. nov., male hypopygium.
50. *Ormosia chankana* sp. nov., male hypopygium.

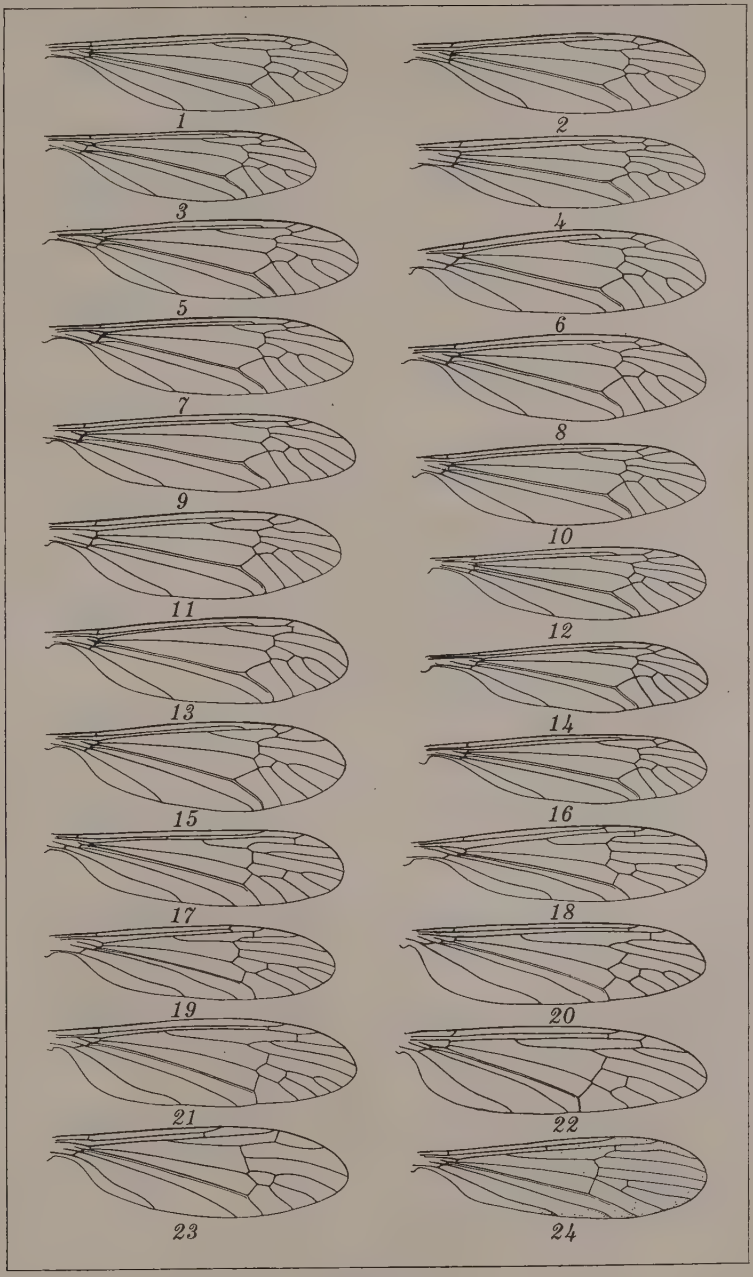
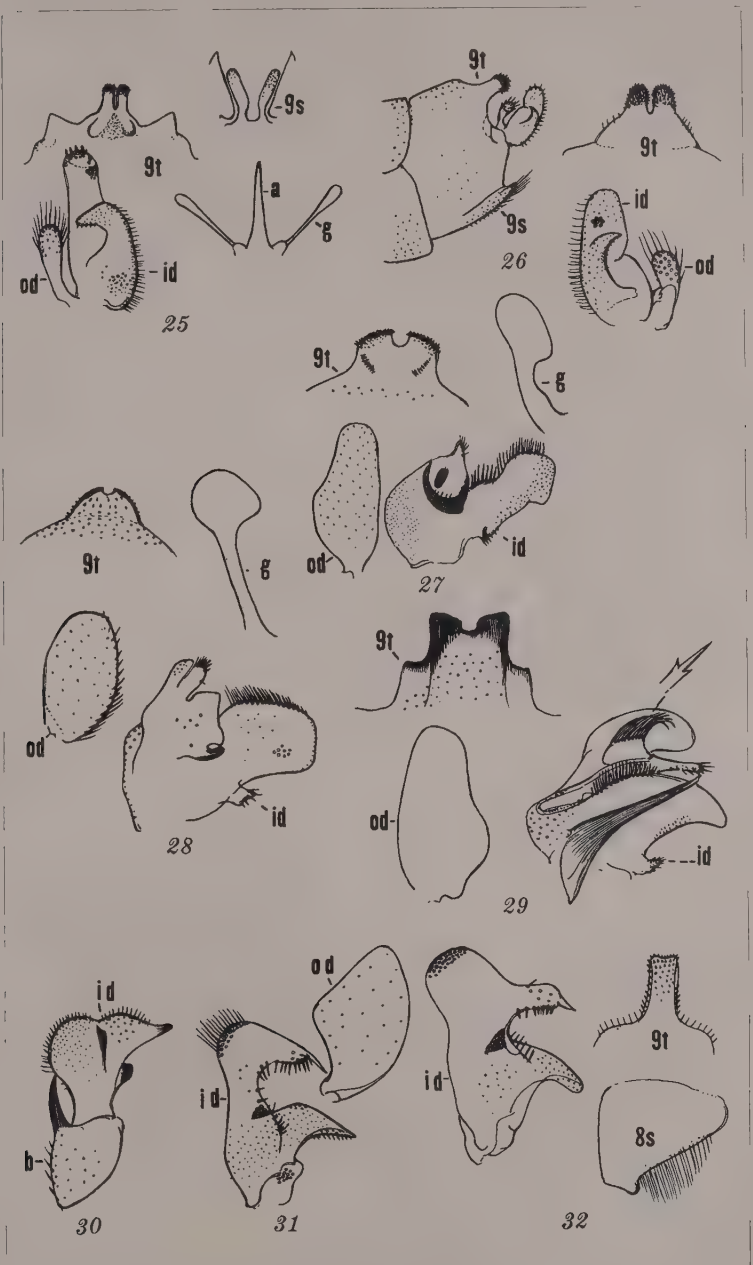


PLATE 1.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id
31
id
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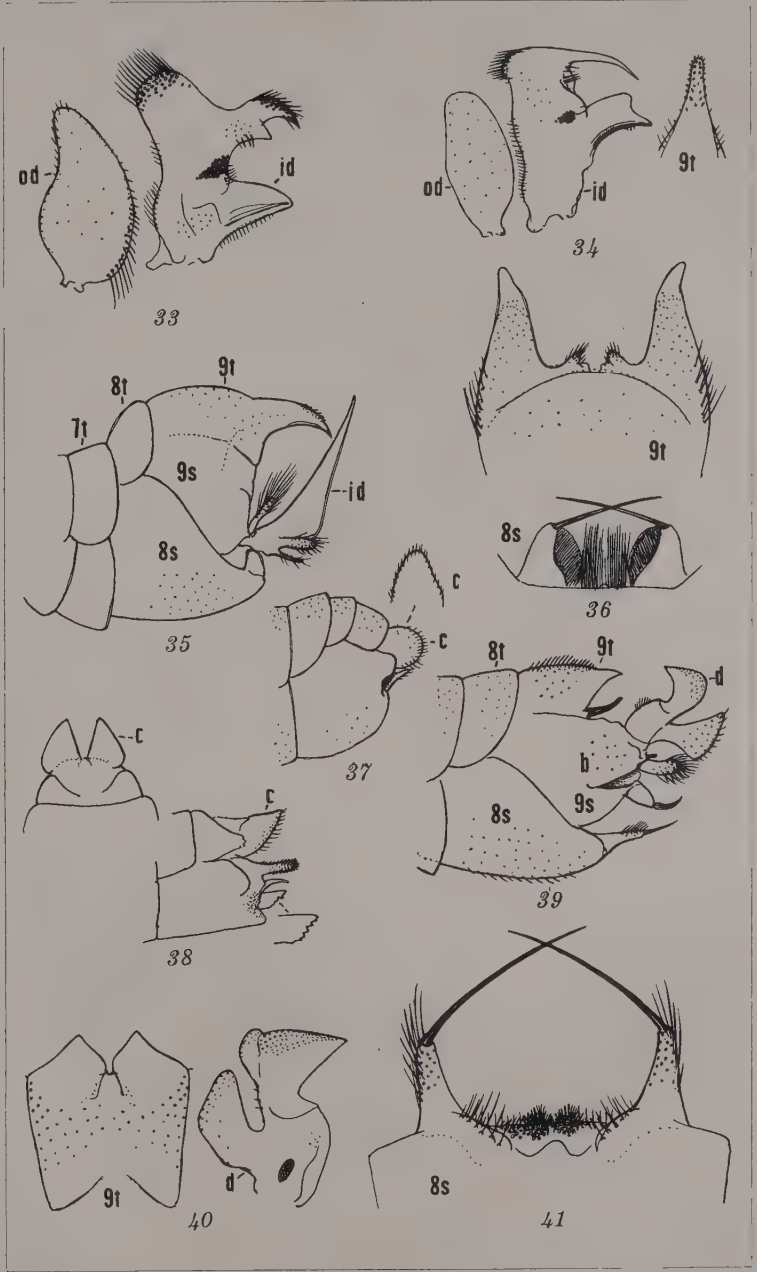
8s
32

PLATE 2.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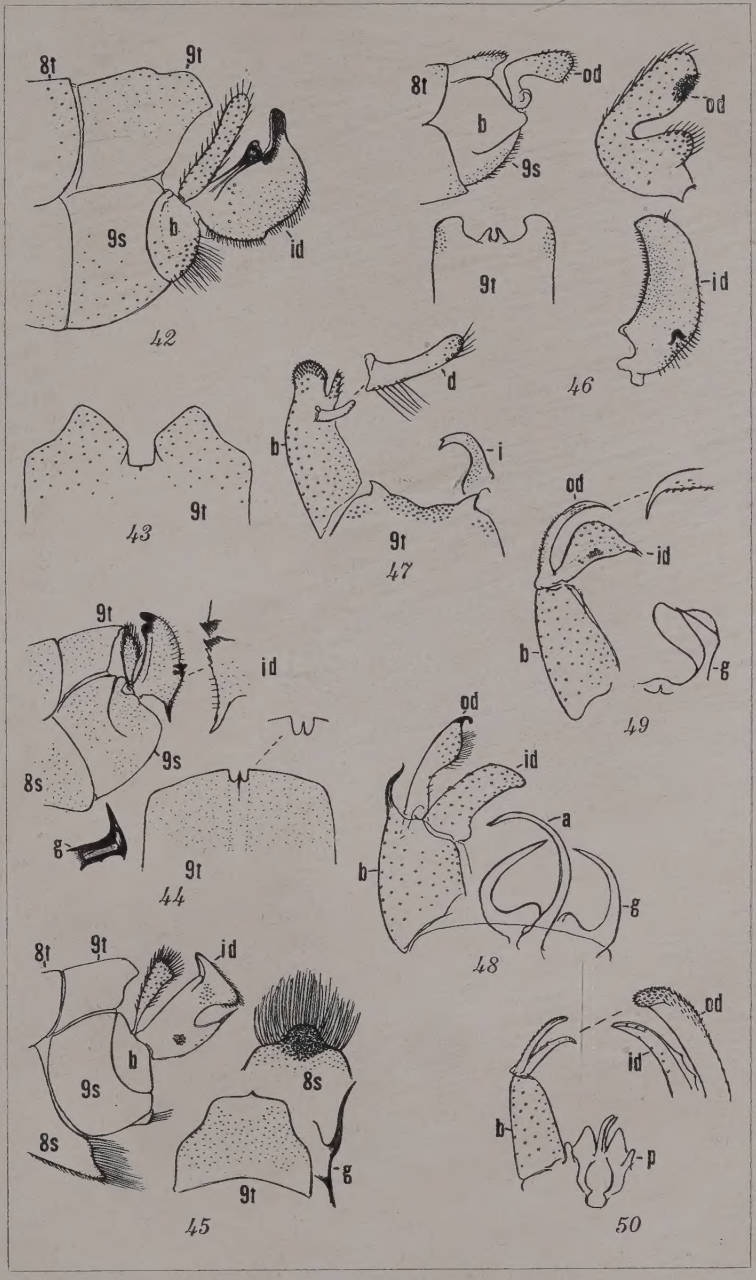
8s
41

PLATE 3.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8s
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9t
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8s
8s
g
9t
45
od
id
b
p
50

PLATE 4.